ROADS AND STREETS

A Gillette Publication—Established 1906

Vol. LXXVI *Chicago, May, 1933* *No. 5*

A 42-inch grader with auxiliary motor to drive the belt, loading seven-yard tandem units. Note the efficient handling of the hauling units—the units following each other closely to keep the exchange time at a minimum.

Economics of Elevating Grader Operation *In Highway Construction*

By T. C. THEE

Assistant Highway Engineer, Division of Management, Bureau of Public Roads

IN principle, the elevating grader has not had a radical change since its conception. The machine still consists of a plow—generally a disc plow—mounted on a heavy frame, which in turn is mounted on four wheels so that the spoil is dropped on a moving belt by which it is elevated to a height from where the material can be dropped into a hauling unit or cast into the fill.

Up to five years ago, the power for driving the belt was imparted by the bull wheel as the elevating grader was hauled over the ground by means of a tractor or teams. This method of operating the belt was very inefficient and, as a consequence, the machine did not function properly in loose, dry sand or in wet ground, as neither provided sufficient traction to enable the bull wheel to operate the belt.

A few graders at this time did have an independent power plant for the operation of the belt but they were not in common use because of the amount of engine trouble experienced. A power takeoff from the differential of the tractor then came into use. This was not entirely satisfactory because of the amount of power lost by the tractor.

The auxiliary engine has now largely taken the place of the power takeoff and the grader is going through a period of standardization of the auxiliary engine mounted on the grader to operate the belt. Larger motors are replacing the smaller motors, which were underpowered for the given belt width at full plow capacity, and as large as 50-horsepower motors are being used to operate a 48-inch belt.

During this process of development, the elevating grader, of necessity, has increased in size and weight and as a consequence larger tractors have been designed to pull it. The horse-drawn 1½ and 2 yard hauling units have practically disappeared and in their place we find the tractor-drawn metal units varying in size from 4 yards to 7 yards, operating as single and as tandem units. This mechanizing of the whole elevating grader outfit, the use of the auxiliary motor, larger graders, and larger tractors have all contributed toward increasing production almost four times over that which was obtained by the tractor-drawn, bull wheel-driven 36-inch belt grader using the 1½ yard team-drawn wagons for hauling units.

Even today the elevating grader has its peculiar field, which is the handling of clay and loam in level to rather heavily rolling country. It is not well adapted to work in rugged country where the slopes are steep and changes in slope abrupt. Its best field is excavating in new locations—particularly in those regions, such as the Mississippi Valley, where the soils are deep and rocks and boulders are seldom encountered.

The contractor must consider his elevating grader as an excavating machine, and his hauling supply as a means of hauling the material excavated; therefore, his problem generally involves the proper coordination of at least

three distinct divisions: (1) the material must be dug and loaded into the hauling units at or near the maximum rate of production for the material handled and for the given length of cut; (2) the distance the earth must be hauled; and (3) the hauling unit supply which must be provided in order to move this production over this distance.

Operation of the Grader.—The grader is operated in a cut by following a definite loop. This loop is composed of a cut down one side, a turn at the end of the cut, a cut up the other side, and another turn. Sometimes it is only possible to cut one side of the loop and it is necessary to "dead head" up the other side of the cut, which results in lost time and a considerable reduction in production.

While operating in the loop, the grader follows a definite cycle of loading the hauling units, stopping to exchange hauling units, and turning at the ends of the loop. The time required to load a hauling unit is dependent upon the size of the load carried by each unit, the cross sectional area of the plow cut, and the speed of the grader.

Theoretical Capacity of the Elevating Grader.—The theoretical capacity of an elevating grader can be computed from the product of the cross-sectional area of the plow cut and the speed of the grader. Generally speaking, the trend in grader performance due to the departure from the use of the bull wheel to drive the belt, shows that the possible area of the plow cut has been increased almost three times while the speed of the tractor which draws the grader has remained relatively constant.

The possible speed of the grader and the possible cross-sectional area of the plow cut which can be attained by the different sizes of graders and tractors under comparable conditions are summarized as follows:

TABLE I

Size of belt inches	Belt Power	(A) Area of plow cut sq. ft.	(S_e) Speed of grader in ft./sec.	($A \times S_e$) Cu. ft. of material moved per second	Cu.yds./hr. (No exchange or turning time considered)
42	Bull wheel.....	0.40	3.50	1.40	187
42	Power take off....	0.70	3.00	2.10	280
42	48 hp. Aux. motor	1.00	3.20	3.20	426
*48	48 hp. Aux. motor	1.30	3.20	4.16	555

*Larger 65 to 70 hp. tractor used for pulling grader.

The use of the bull wheel to operate the belt after the tractor was used to pull the grader was an adoption from the time when the grader was pulled by 16 to 20 horses. The use of 1½ to 2 cubic yards horse-drawn wagons has practically disappeared altogether, and the large sized tractor-drawn metal wagons have taken their place.

A large plow cut could not be made when the belt was driven by the bull wheel, because of the limitation of the bull wheel in maintaining traction as the plow shaker attempted to increase the plow bite. The unused power of the tractor was used in maintaining a relatively high speed for the grader.

The power takeoff from the tractor, which took the place of the bull wheel for operating the belt, resulted in a more direct driving of the belt. The power takeoff reduced the tractor power upwards of 15 horsepower, however, and as a consequence reduced the speed of the tractor. The area of the plow cut was increased from 0.4 square feet to 0.7 square feet, and the speed of the grader was reduced from 3.50 feet per second to about 3.00 feet per second. This resulted in a net gain in production as well as in eliminating, to a large degree, belt clogging.

With the advent of the auxiliary motor mounted on the grader to operate the belt, small motors of 15 horsepower were first used, but these, although they increased production, were inadequate for the given capacity of the grader belt for the possible plow cut. The size of these motors was increased until the capacity of the belt width was reached, and the belt width was then increased from 42 to 48 inches, using a larger 65 to 70 horsepower tractor to pull the grader. This in turn increased the possible plow cut from approximately 1.0 square foot to 1.3 square feet, with the speed of the grader remaining the same. On the 48-inch belt graders 50-horsepower auxiliary motors are being used and in some cases the contractors are using up to as high as 60-horsepower auxiliary motors to operate the belt.

Up to 1932, the plow and belt carrier control were operated manually by the plow shaker. During 1932 several graders have been built with the plow control and all other adjustments operated by a power control from the auxiliary engine. A series of levers conveniently located by the grader operator's seat makes the task of the plow shaker relatively an easy one and greatly increases the possible efficiency of the operations.

Production Studies.—The Division of Management of the U. S. Bureau of Public Roads over a period of years has made careful stop-watch studies of going elevating grader jobs operating under different conditions and using different types and sizes of elevating graders and hauling units. Table II is a summary of the results of studies made on a few of these jobs which were considered more or less comparable and had certain characteristics of operation which would be valuable to discuss.

The data relative to the loading, exchanging and turning times are the averages obtained from the detailed stop-watch studies made of the grader operation. The loading time is the average time in seconds to load the hauling unit. The exchange time is the average time in seconds to exchange the single unit or the double exchange time of the tandem hauling unit. The turning time is the average time in seconds required to turn the grader each time at the end of the loop.

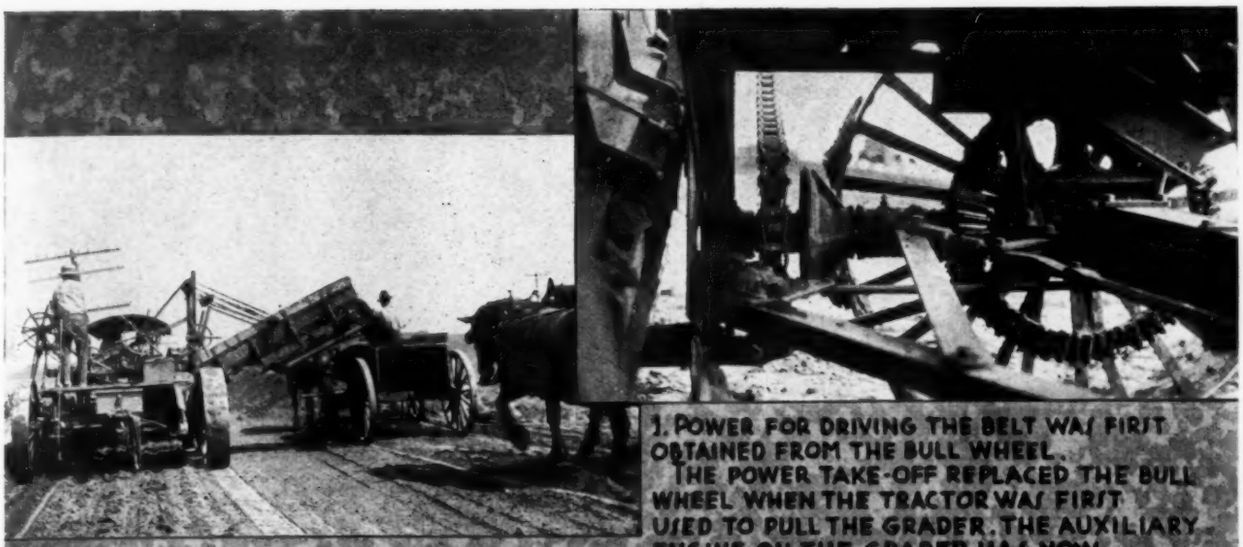
The average size load measured in place in the cut hauled by the hauling unit was determined by cross-sectional measurement. Knowing the average distance in feet the grader travels to load one of these hauling units, the average cross-sectional area of the plow cut was determined. Knowing the loading time and the distance traveled by the grader, the average grader speed in feet per second was obtained.

A careful record was made of the daily and hourly production. In Table II the actual cubic yards loaded per hour while the elevating grader was actually operating is given, and in addition the theoretically possible production in cubic yards per hour is computed for an ideal grader which could operate without any delays whatsoever—or, in other words, at 100 per cent time efficiency. The average length of cut is shown in feet.

From the stop-watch studies, the percentage of major and minor delays that occurred are shown in the table. The major delays represent time losses of 15 minutes or more in duration. The minor delays are delays of less than 15 minutes. If a delay could not reasonably have been eliminated it was recorded as a Class A delay. If a delay could have been prevented by ordinary managerial foresight the delay was identified as a Class B delay.

Effect of Belt Power on Production.—Generally speaking, the one item which has increased the production more than any other in elevating grader work has been the auxiliary motor to operate the belt.

Due to the amount of slippage of the bull wheel, caused



1. POWER FOR DRIVING THE BELT WAS FIRST OBTAINED FROM THE BULL WHEEL. THE POWER TAKE-OFF REPLACED THE BULL WHEEL WHEN THE TRACTOR WAS FIRST USED TO PULL THE GRADER. THE AUXILIARY ENGINE ON THE GRADER HAS NOW REPLACED THE POWER TAKE-OFF.

2. THE 36-INCH BELT GRADER HAS BEEN REPLACED BY THE 42-INCH BELT GRADER.

3. THE TRACTOR DRAWN HAULING UNIT HAS PRACTICALLY REPLACED THE TEAM AND WAGON UNIT.

4. A 42-INCH BELT GRADER WITH POWER TAKE-OFF LOADING SEVEN YARD TANDEM UNITS.

5. A NEW 48-INCH BELT GRADER LOADING SEVEN YARD TANDEM UNITS. THE GRADER IS EQUIPPED WITH A FIFTY HORSE POWER AUXILIARY ENGINE WHICH DRIVES THE BELT AND THE POWER LEVER CONTROLS.

6. ANOTHER TYPE OF 48-INCH BELT GRADER WITH POWER LEVER CONTROLS. NOTE THE LOCATION OF THE AUXILIARY MOTOR WHICH FURNISHES THE POWER FOR THE BELT AND THE POWER CONTROLS.

7. LOADING FIVE YARD TANDEM UNITS WITH A POWER DRIVEN BELT GRADER.

TABLE II

SUMMARY OF ELEVATING GRADER PRODUCTION STUDIES

STATE	Wis-consin	Minne-sota	Minne-sota	Wis-consin	Minne-sota	Wis-consin	Wis-consin	Wis-consin	Minne-sota	Minne-sota	Ne-braska	Iowa	Minne-sota	Ne-braska
Project Number	3-C	2-A	1-A	2-C	4-A	3-A	1-C	1-A	1-B	2-B	1-A	2-A	3-B	3-A
Tractor	3	2	4	3	1	1	3	1	1	1	1	1	1	1
Elevator belt width	48"	48"	48"	42"	42"	42"	42"	42"	42"	42"	42"	42"	36"	36"
Belt power	50 hp.	36 hp.	36 hp.	50 hp.	48 hp.	48 hp.	32 hp.	20 hp.	15 hp.	P. T. O.	P. T. O.	B. W.	B. W.	B. W.
Loading time, seconds	42.8	75.7	89.6	47.1	107.6	111.0	47.7	69.6	61.1	152.1	134.9	26.2	21.0	24.5
Exchange time, seconds	9.85	14.5	14.4	9.01	13.6	14.9	9.35	8.4	18.1	22.0	18.8	6.85	6.6	7.75
Turning time, seconds	42.2	43.5	44.8	42.2	37.9	38.3	43.4	40.4	55.6	45.0	43.9	40.7	45.7	47.6
Area plow cut, sq. ft.	1.34	1.25	1.09	1.20	0.91	0.88	1.10	1.00	1.35	.655	.615	.394	.386	.320
Grader speed, ft./sec.	3.08	3.19	3.12	2.66	3.29	3.20	2.69	2.56	1.925	3.04	2.74	3.37	3.51	3.52
Haul unit load, cu. yds.	6.37	11.18	11.30	5.54	11.92	11.54	5.22	6.60	6.00	11.2	8.40	1.30	1.06	1.02
Type of hauling unit	7-yd. Singles	7-yd. Tandems	7-yd. 4 & 7-yd. Singles		7-yd. Tandems	7-yd. Tandems	4 & 7-yd. Singles	7-yd. Singles	7-yd. Singles	7-yd. Tandems	5-yd. Tandems	1½-yd. Teams	1½-yd. Teams	1½-yd. Teams
Distance to load, ft.	129	242	280	125.0	348	356	128.2	178	120	462	134.9	88.5	73.8	86.2
Actual cu. yds. per hour	255	212	224	206	226	207	203	196	154	120	124	87.6	53.0	74.0
Cu. yds./hour, no delays	361	315	296	256	304	279	240	246	216	168	170	93.0	86.0	96.0
Average length cut, ft.	382	234	316	191	548	588	263	282	216	238	193	163	116	577
Per cent major "A" delays	0.00	7.57	10.06	18.6	2.72	8.26	18.6	6.83	11.57	9.66	9.24	23.32	14.58	25.58
Per cent minor "A" delays	2.20	16.22	12.29	14.1	12.53	17.43	14.1	14.10	21.25	22.22	23.38	14.52	23.20	14.33
Per cent major "B" delays	0.00	1.19	3.09	0.6	0.00	0.83	0.6	0.00	0.08	1.14	0.21	2.92	14.42	1.44
Per cent minor "B" delays	27.0	16.33	12.18	8.3	12.87	8.23	8.3	6.02	7.36	5.63	3.91	7.82	10.86	8.05
Cu. yds./hr.—No delays—														
Length of cut, 100 feet	243	226	194	204	187	159	186	176	174	122	151	76.0	74.0	68.0	80.0	55.0
250 feet	330	322	279	274	261	231	252	236	222	171	175	108	104	97	105	80
500 feet	376	374	326	310	301	272	286	266	245	197	185	125	120	114	117	94
750 feet	394	396	345	324	316	289	299	278	254	207	189	133	127	121	122	100
1000 feet	404	407	355	332	325	298	306	284	258	213	191	137	130	125	125	103
Cu. yds. per hour no delays, no turning or exchange time	550	532	454	426	400	376	394	341	353	266	225	186	177	181	183	150
Type of soil	Clay	Clay	Sandy Clay & Clay	Sandy Clay	Sandy Clay	Clay	Sandy Clay	Sandy Clay-Gravel	Sand & Clay	Sandy Clay	Sandy Clay	Clay Loess	Clay Loess	Black Clay Loam	Sandy Clay	Clay Loess

by the plow taking too large a bite, and the constant fouling of the belt, the only method left to obtain as high production out of the grader as possible was to operate the grader at a high speed and take a relatively light plow cut. The horse-drawn graders operated at approximately 3.75 feet per second and very rarely did the plow cut exceed ½ square foot in area. When the tractor replaced the horses, hardly an appreciable increase in production was noted, because the tractor did not reach so high a speed of travel, as the horses, and it was almost impossible to increase the area of the plow cut because the same bull wheel slippage occurred whether the grader was horse drawn or tractor drawn.

The power takeoff from the differential of the tractor to operate the belt eliminated the trouble which resulted when the bull wheel was used to operate the belt. However, the power takeoff reduced the tractor power, and, as a consequence, reduced the speed of the tractor, but slightly increased the plow cut area.

When the auxiliary engine was used to operate the belt, the possible area of the plow cut was doubled and the speed of the grader increased. Small 15-horsepower motors were first used for the auxiliary engine but it was soon found that they were underpowered for the possible capacity of the belt when provided with an independent drive. As a result the size of these engines was increased until 50-horsepower engines were used with the 42-inch belt grader, and as a consequence the area of the plow cut, or "bite" was increased until the carrying capacity of the belt was reached. The 48-inch belt grader was then developed and 65-70 horsepower tractors for pulling it.

The use of the large-sized hauling units has also resulted in increasing production. This is due to the fact that less time is lost due to exchange time.

The 48-inch belt grader using a 50-horsepower auxiliary motor on Wisconsin Project 3-C could produce 550 cubic yards an hour if the exchange time and the turning time could be eliminated. But the present elevating grader design prevents the possibility of operating without time lost due to exchanging hauling units and turning the grader. If the grader could be designed so as to shuttle back and forth without turning after making one pass down the one side of the cut, and if a "gob-box" or hopper could be provided to eliminate exchange time, a theoretical capacity of 550 yards per hour could be obtained. Because of turning and exchange time this production is reduced to 243 cubic yards an hour in a 100-foot cut, to 330 yards in a 250-foot cut, to 376 yards an hour in a 500-foot cut, to 394 yards in a 750-foot cut, and to 404 yards in a 1,000-foot cut. If the exchange time could be eliminated, the production would be increased 10 per cent on a 250-foot cut

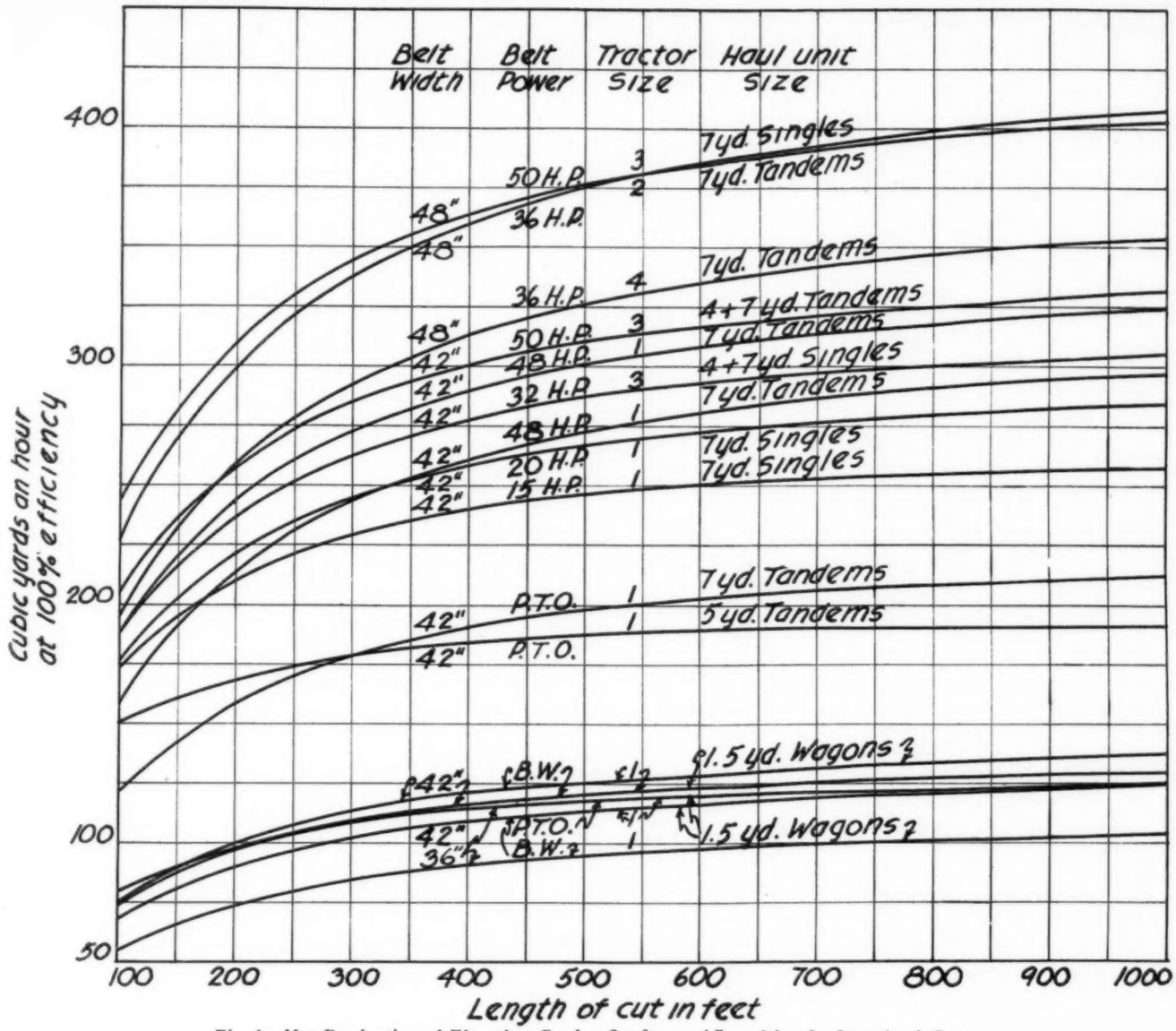


Fig. 1—Net Production of Elevating Grader Outfits as Affected by the Length of Cut

and 15 per cent on a 1,000-foot cut. The use of the large sized hauling unit has greatly reduced the time lost due to exchange time as compared with the 1½ yard hauling unit.

Figure 1 is a graphical summary of the possible production of the grader jobs shown in Table II for variable lengths of cut with the graders assumed to be operating at 100 per cent time efficiency. The material in which the graders operated varied from clay to sand-clay. This graph shows to what extent the combined effect of belt power and the use of large sized hauling units has on production. The use of the larger sized 65-70 horsepower tractor has also had considerable effect in increasing production. These theoretically possible rates of production are, of course, seldom approached because of delays of one type or another, all of which are dependent upon supervision, and it is usually these delays which determine whether a profit or a loss will result.

The data graphically shown in Figure 1 were collected on jobs where good to excellent management was exercised and the speed of the grader, the plow cut, exchange time, and turning time, as shown in combination and expressed in cubic yards obtained, approach very closely to maximum possible. No account is made in this graph for delays so that all jobs could be summarized on the basis of 100 per cent operating efficiency insofar as major and minor delays were concerned.

These contractors employed the best possible plow-shaker and grader-tractor operator, as well as experienced tractor operators for the hauling units; yet, four sources of production loss can be traced to these operators: (1) Failure to maintain full cross section while cutting; (2) failure to maintain full speed while moving; (3) failure to exchange hauling units rapidly at the grader; and (4) negligence in turning the grader unit rapidly at the ends of the loop.

Effect of Plow Cut Area on Production.—The failure of the plow shaker to maintain the maximum sized plow cut for the given grader capacity and type of material results in a large reduction in production. Figure 2 shows graphically the effect of plow cut area on production for different lengths of cut. By increasing the plow cut area 0.2 square foot, production is increased 35 cubic yards an hour for a 100-foot cut and about 50 cubic yards an hour for cuts of 250 feet or more.

The 42-inch width belt grader using a larger auxiliary motor should never be allowed to operate with less than a 1 square foot plow cut area in average material. There are too many contractors who allow this loss to continue without correction.

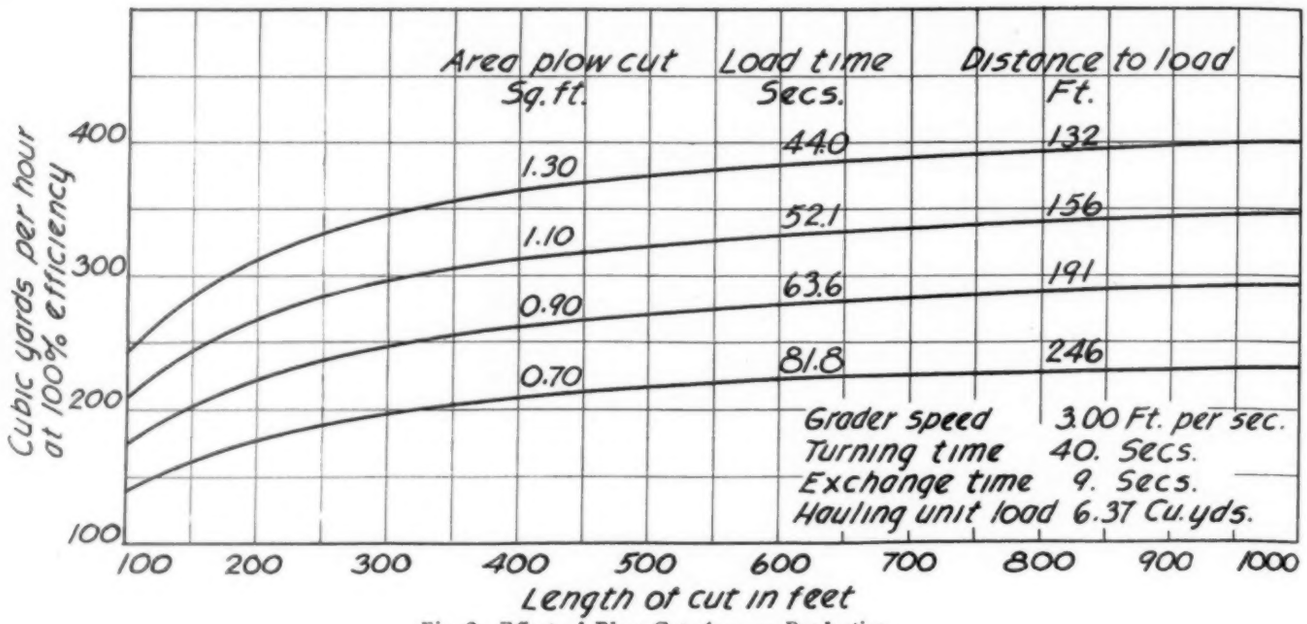


Fig. 2—Effect of Plow Cut Area on Production

Likewise, when using a grader having a 48-inch belt driven by a large 50-horsepower auxiliary motor, the plow shaker should attempt to maintain an average plow cut area very close to 1.30 square feet in average clay to sand-clay material.

The resulting effect on loading time is also shown in Figure 2. If the plow cut area became 1.10 square feet instead of 1.30 square feet, the loading time would be increased from 44 seconds to 52.1 seconds or a total loss of over 8 seconds per 7-yard hauling unit. If the plow cut area were reduced to 0.90 square foot, the loading time would be increased to 63.6 seconds. The distance required to load a hauling unit is likewise increased, which has an additional effect of further delaying hauling unit and grader operations, especially on short cuts, because the hauling unit has to follow the grader around the end of the loop, which delays the hauling unit an additional 40 to 45 seconds.

Securing the largest possible bite is of the utmost importance since so large a part of the theoretical as well as practical capacity of the machine can be lost—all of which serves to emphasize the necessity for giving the closest attention to the bite in order to insure, under all circumstances, the taking of the largest possible cut.

The necessity for securing the largest possible bite would not be so important were it not for the fact that the elevating grader is more or less a constant speed machine. The general practice is to establish a working speed and then to maintain that speed. The failure to take out a full bite, therefore, causes a loss of time and production which cannot be compensated by faster moving. This loss cannot be regained by greater efficiency in any of the other parts of the work; it, therefore, is a dead loss.

Grader Speed.—Tractors pulling an elevating grader can normally maintain a speed of about 3 feet per second. With the use of the larger 65-70 horsepower tractor, the grader speed is increased to 3.25 feet per second. Due to either poor maintenance of the tractor or poor operation, too many graders are operated at speeds less than 3 feet per second—and sometimes reach a speed as low as 2.5 feet per second—while at the same time obtaining a small plow cut.

Figure 3 shows graphically the effect of grader speed on production for different lengths of cut. For average lengths of cut, by increasing the grader speed 0.25 foot per second production will be increased approximately 20 cubic yards an hour or 200 cubic yards in 10 hours of operation, which is a worthwhile saving. However, it is essential for maximum production to secure the max-

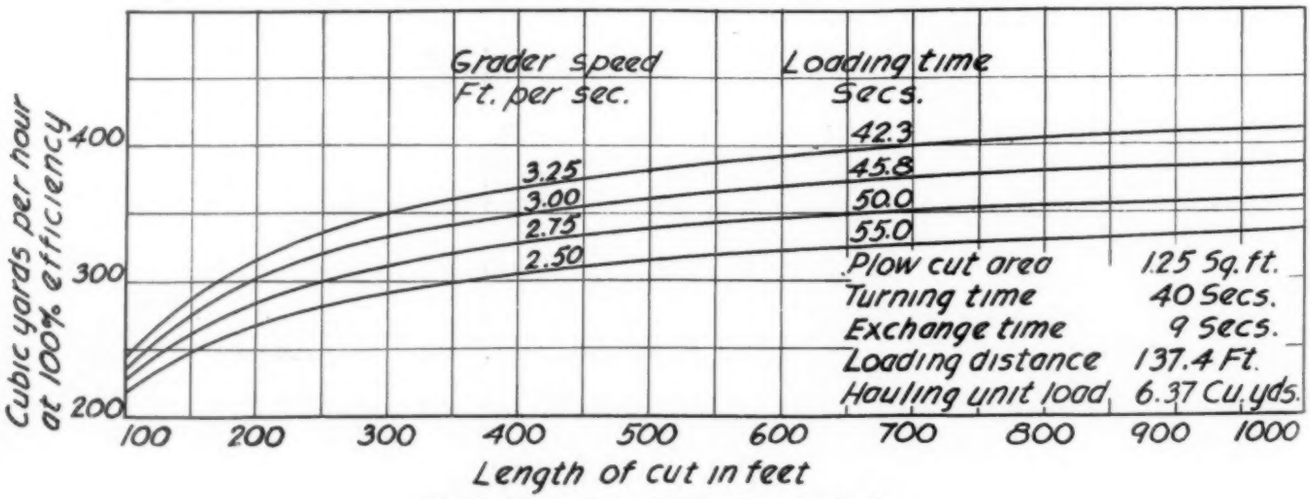


Fig. 3—Effect of Grader Speed on Production

imum possible bite rather than to keep the size of the plow cut the same and use the extra power for increased grader speed.

Minimum Exchange Time Essential.—Loss of time due to exchanging units at the grader has been reduced considerably by the use of the large sized hauling units. Time lost due to exchanging 1½ yard wagons consumed from 30 to 40 per cent of the actual operating time. The use of the large sized hauling units has reduced this loss to 10 to 20 per cent of the actual operating time.

If the grader could be so redesigned that no time were lost due to exchanging the hauling unit at the grader, the production would be constant regardless of the size of the hauling unit and the only factor that would be involved in their selection would be the cost of operating back and forth to and from the fill.

If the required number of hauling units are available for the given length of haul and for the output of the grader, 1½ yard wagons can be exchanged in 6 seconds, 5-yard singles in 8 seconds, and 7-yard singles in about 9 seconds. If the 5 or 7 yard units are operating in tandem there is a double exchange time involved, between the individual units in the tandem and between the tandem units. The total double exchange time for the 5-yard tandem units is about 13 seconds, and the double exchange time for the 7-yard tandem units is about 14 seconds.

The hauling units should be loaded so that the load is finished with the belt on the end of the unit. If the exchange time is reduced, the grader output is increased; therefore, it is essential that enough hauling units are available to take advantage of the increased production. It is essential that there be enough hauling units on the job so that savings made through efficient exchange are not lost or at once obliterated by inadequacy of the hauling unit supply.

Figure 4 shows for the different sized hauling units the percentage of time spent in loading, exchanging, and turning. The possible production is also shown. Analyzing the factors that affect the possible output of the grader using different sized hauling units, one must first consider the fact that the production of the grader would be the same regardless of the size of the hauling unit if the grader did not lose time because of the turning or exchanging. Likewise, the grader production would remain the same if the time lost due to turning the grader was necessary but the exchange time was eliminated. Thus, the basic reason for the difference in possible production for the grader using the different sized hauling units, is due, generally speaking, to loss in exchange time. For example, on a 500-foot cut the percentage of operating time lost which is due to exchange time amounts to 34.7 per cent for 1½ yard units, 18.2 per cent for 5-yard units, 15.2 per cent for 5-yard tandem units, 14.2 per cent for 7-yard units, and 11.5 per cent for 7-yard tandem units. For 7-yard units the longest exchange time is 9 seconds.

For the grader used in the graphical example shown in Figure 4 the grader speed and cross-sectional area of the plow cut is 3 feet per second and 1.25 square feet, respectively. This grader produces 3.75 cubic feet or 0.139 cubic yards of material per second. If a gob-box or other means is to be provided to take care of the elapsed production in eliminating the exchange time for a 7-yard unit, this gob-box must hold at least 1.25 cubic yards. If this gob-box could hold 0.694 cubic yards of material at least 5 seconds might be eliminated from the exchange time, which would result in a large increase in production, particularly for the smaller sized hauling units.

Effect of Turning Time.—Figure 4 also shows graphically the percentage of the possible operating time lost due to turning the grader. The reason that only one line is shown for this is due to the fact that the exchange

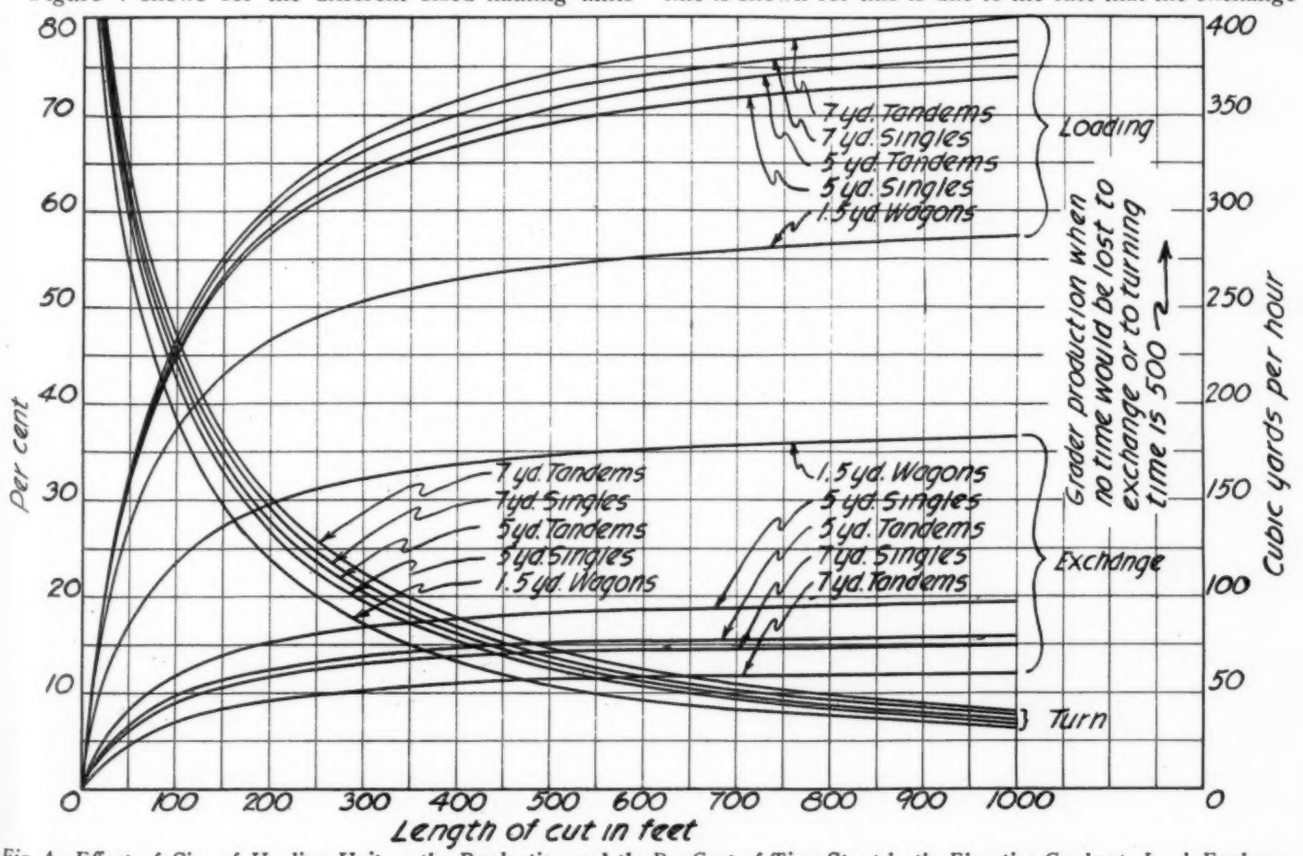


Fig. 4—Effect of Size of Hauling Unit on the Production and the Per Cent of Time Spent by the Elevating Grader to Load, Exchange and Turn for Variable Lengths of Cut

time also affects the loss due to turning time. The grader can be turned at the end of the loop consistently within 40 seconds if the tractor operator is experienced. Even keeping the turning time at this figure, the percentage of time lost due to turning the grader when using the large units amounts to about 45 per cent in a 100-foot cut, 25 per cent in a 250-foot cut, almost 15 per cent in a 500-foot cut, and about 8 per cent on a 1,000-foot cut.

A far as the grader is concerned, production is the largest when tandem 7-yard units are used; however, the economical length of cut to operate tandem units and the length of cut where single units are the most economical will be discussed later.

Time Losses.—A summary of the time losses recorded during the stop-watch studies of the elevating grader jobs is shown in Tables III and IV.

Table III is a summary of the time losses for the graders operating with 1½ and 2 yard horse-drawn wagons. A total of 26.24 per cent of the available working time was lost by delays of 15 minutes or more in duration. A total of 23.04 per cent of the time the grader operated without major delays was lost because of delays of less than 15 minutes.

The management was responsible for 8.08 per cent of the lost actual operating time. Of this, 4.75 per cent was lost because of an insufficient number of hauling units and the operation of the hauling units, all of which could have been eliminated under good management.

Table IV shows that 10.44 per cent of the available working time was lost due to major delays where large sized hauling units were used. A total of 5.34 per cent of the available working time was lost due to elevator and grader repair. Most of the repair was due to belt trouble. With the belt operated at a relatively high speed by the larger auxiliary motors, the wear on the belt became excessive. In some gravelly soils the life of the belt is only about two weeks. This is a very expensive item.

Minor delays totaled 25.48 per cent on these jobs, 8.38 per cent of which could have been avoided. A total of 6.94 per cent was due to not having a sufficient supply of hauling equipment and to the operation of the hauling units. Lost time due to dead-heading amounted to 5.38 per cent on the jobs using the small hauling units and to 6.45 per cent on the jobs using the large hauling units. These are losses which can be expected on practically all of the elevating grader jobs using the present type of grader, because of the fact that ground worked over is seldom level and it is sometimes customary to take a full bite only on one side of the cut since the floor of the cut must be reached on a level cross section.

The hauling unit cycle consists of loading time, travel time, the time required to turn and dump, and miscellaneous delays. The time required to load a hauling unit is dependent upon the size of the hauling unit, the speed of the grader, and the area of the plow cut.

Under good management, using a 48-inch belt grader and an auxiliary motor to operate the belt with a 65-70 horsepower tractor to draw the grader, the 7-yard tandem hauling unit should be loaded in 87 seconds, a 7-yard single unit in 44 seconds, a 5-yard tandem unit in 61 seconds, and a 5-yard single unit in 31 seconds. The 1½ yard wagons should be loaded in 10 seconds.

Using a 42-inch belt grader equipped with an auxiliary motor to operate the belt and a 65-70 horsepower tractor to draw the grader the 7-yard tandem unit should be loaded in 108 seconds, a 7-yard single unit in 54 seconds, a 5-yard tandem unit in 76 seconds, a 5-yard single unit in 38 seconds, and 1½ yard wagon in 12 seconds.

To determine the hauling unit time constant the loading time is added to the time spent in turning the unit at

TABLE III—GENERAL SUMMARY TIME LOSSES

1½ Cubic Yard Wagons

TOTAL MAJOR DELAYS OCCURRING DURING AVAILABLE WORKING TIME

Character	Class A Hours	Class A Per Cent	Class B Hours	Class B Per Cent	Totals Hours	Totals Per Cent
Wet grade	168.60	8.76	....	....	.....	....
Rain	98.95	5.14	....	....	.....	....
Moving	24.85	1.29	....	....	.....	....
Check grade	18.85	0.98	....	....	.....	....
Rest stock	15.48	0.80	....	....	.....	....
Grader repair	11.63	0.60	....	....	.....	....
Tractor repair	8.80	0.46	....	....	.....	....
Engineering	5.75	0.30	....	....	.....	....
Elevator repair	2.20	0.11	....	....	.....	....
Miscellaneous	64.19	3.34	85.97	4.46	.....	....
Totals	419.30	21.78	85.97	4.46	505.27	26.24
Time major equipment actually operated					1419.08	73.76
Total available working time					1924.35	100.00

TOTAL MINOR DELAYS OCCURRING DURING TIME EQUIPMENT ACTUALLY OPERATED

Deadheading	76.33	5.38	....	....	.....	....
Hauling, supply	49.00	3.46	40.02	2.82	.....	....
Hauling, op'r'tion	.....	....	27.34	1.93	.....	....
Grader, repair	18.68	1.32	4.40	0.31	.....	....
Grader, operation	.....	....	11.91	0.84	.....	....
Resting stock	9.62	0.68	....	....	.....	....
Elevator trouble	7.94	0.56	....	....	.....	....
Elevator repair	4.97	0.35	....	....	.....	....
Miscellaneous	45.81	3.24	30.81	2.18	.....	....
Totals	212.35	14.99	114.48	8.08	326.83	23.07
Time major equipment operated at 100% efficiency					1092.25	76.93
Grand total all Class B losses					200.45	....
Possible operating time, all Class B losses eliminated					1292.70	....
Overall efficiency of major equipment operation					.....	84.50

TABLE IV—GENERAL SUMMARY TIME LOSSES

4 to 7 Cubic Yard Wagons

TOTAL MAJOR DELAYS OCCURRING DURING AVAILABLE WORKING TIME

Character	Class A Hours	Class A Per Cent	Class B Hours	Class B Per Cent	Totals Hours	Totals Per Cent
Elevator repair	98.72	3.12	....	....	.....	....
Grader repair	70.46	2.22	....	....	.....	....
Rain	65.55	2.08	....	....	.....	....
Wet grade	32.12	1.02	....	....	.....	....
Moving	26.78	0.84	....	....	.....	....
Tractor repair	2.96	0.09	....	....	.....	....
Miscellaneous	16.65	0.53	17.23	0.54	.....	....
Totals	313.23	9.90	17.23	0.54	330.46	10.44
Time major equipment actually operated					2831.27	89.56
Total available working time					3161.73	100.00

TOTAL MINOR DELAYS OCCURRING DURING TIME EQUIPMENT ACTUALLY OPERATED

Deadheading	182.94	6.45	4.24	0.15	.....	....
Hauling Unit:						
Supply	70.22	2.48	136.43	4.82	.....	....
Operation	46.39	1.64	60.12	2.12	.....	....
Rocks and stumps	39.25	1.39	....	....	.....	....
Grader repair	32.93	1.16	....	....	.....	....
Elevator trouble	31.83	1.13	6.59	0.23	.....	....
Elevator repair	19.26	0.68	....	....	.....	....
Grader operation	.....	....	12.25	0.43	.....	....
Wet grade	8.08	0.27	....	....	.....	....
Miscellaneous	53.44	1.88	17.90	0.63	.....	....
Totals	484.34	17.08	237.53	8.38	721.87	25.46
Time major equipment operated at 100% efficiency					2109.40	74.52
Grand total of Class B time losses					254.76	....
Possible operating time all Class B losses eliminated					2364.16	....
Overall efficiency of major equipment operation					.....	88.70

the grader and at the dump, the time required in dumping the unit, the delays that occur at the dump and at the grader. From stop-watch studies conducted on the hauling unit, it was determined that under good management the time spent in loading a 7-yard single unit, loading from a 48-inch belt grader is 44 seconds; the time to turn at the grader is 25 seconds; the time required to dump is 15 seconds; the time to turn at the dump is 20 seconds, and the time lost to miscellaneous delays will average about 46 seconds.

The 7-yard tandem unit time constant will be approximately 290 seconds, the 5-yard tandem unit time constant 200 seconds, the 5-yard single unit constant 115 seconds, and the time constant for a 1½ yard wagon 80 seconds.

Speed of Hauling Unit.—From the time studies the average speed of the hauling unit was found to be 4.2 feet per second for a 7-yard tandem unit, 4.6 feet per second for a 7-yard single unit, 4.3 feet per second for a 5-yard tandem unit, 4.7 feet per second for a 5-yard single, and 4 feet per second for a 1½ yard wagon using 3-ups. The 60 horsepower tractor was used in pulling the 7-yard tandem, 7-yard single and the 5-yard tandem. The 30-horsepower tractor was used with the 5-yard single units.

When very loose sand or boggy soil is encountered the 7-yard tandem unit is very difficult to operate and only one 7-yard unit can be used per tractor. The speeds given are for average soil conditions. If the units are operated on firm and well maintained hauling road, the speeds for a 7-yard tandem unit will become as high as 5.5 feet per second.

The effect of tractor speeds on the number of hauling units required for different lengths of haul is especially marked. By operating the tractor at the rate of 1 foot per second faster, approximately one hauling unit can be eliminated. If inefficient operators are employed who do not appreciate the value of lost time nor the need for operating the units at the maximum working speeds for the given conditions, they can make hauling costs result in a large loss in profits.

Hauling Unit Time Losses.—Not only can hauling costs be reduced by operating the hauling units at their proper working speed by proper operation and maintenance of the hauling road, but equally as large a saving can be made by keeping the time losses of the hauling unit at the grader and at the dump down to a minimum. If 100 seconds are saved each round trip of a 7-yard tandem unit, hauling costs are reduced approximately 1 cent per yard, not considering the additional saving by keeping the lost time for the grader at a minimum.

Considering equipment and labor for loading, dumping, finishing, and supervising a three-unit 7-yard tandem outfit costs in the neighborhood of from 50 to 60 cents a minute. It is obvious that with the present-day price for moving dirt it is essential that time losses be reduced to a minimum by proper supervision and operation of the equipment at the rate of speed for which it was designed.

Conclusions.—For the efficient operation of the elevating grader it is essential that careful attention be given to the bite which it takes, the speed at which the grader is moved, the prompt exchange of hauling units with an adequate supply of hauling units, and to keeping the turning time of the grader at a minimum.

The auxiliary engine used to operate the belt must have adequate power, so that the maximum sized plow cut is obtained for the given belt width.

The output of the present type of grader varies greatly with the length of the cut, and it is essential that the contractor scrutinize this detail very carefully and make proper adjustments in his bid price accordingly.

Not only should the best possible operators be employed to operate the grader and its operations be supervised carefully, but the hauling units should be operated at their proper working speeds, and efficiently operated and supervised so that the unit costs are kept at a minimum.

It would be very profitable to a contractor to use the stop-watch frequently over a reasonable period of time and check the following operations:

1. Time to load a hauling unit.
2. Exchange time of hauling units at the grader.
3. Turning time of the grader.
4. Amount of time lost due to delays.

He should also determine the average distance the grader travels to load one hauling unit, as well as the average area of the plow cut and the speed of the grader. These data should be collected for an hour each morning and afternoon for about two weeks, averaging the readings secured. From these data the contractor can carefully revise his method of operation and thereby increase his production and at the end of the season show a better profit by the work he has contracted.

Acknowledgment.—This article was prepared for ROADS AND STREETS but was presented before publication in an address by Mr. Thee before the Iowa branch of the Associated General Contractors of which O. W. Crowley is Executive Secretary.

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Recent State Legislation Regarding Highways

Many laws affecting highways have been passed by state legislatures during their present sessions. Among the recent ones are the following:

California.—Amends Section 2620 of the Political Code to provide that all public highways "except State highways," bridges, alleys and lanes and trails shall be at least 40 ft. wide. The width of all state highways or all roads, avenues, or ways under the control or supervision of the California Highway Commission, excepting bridges and approaches thereto, shall be at least 80 ft. wide. When any bridge or the approaches leading thereto constitute a part of any state highway the Department of Public Works may determine the width thereof.

Idaho.—Repeals Section 39-1549, Idaho Code Annotated, which provided that any highway district having no bonded indebtedness in excess of 10 per cent of its taxable property might levy a special tax not exceeding 40 ct. per $100 taxable value of property within the district for constructing main or trunk highways.

Idaho.—Amends Section 39-601, Code Annotated, to provide that all highways, except alleys and bridges and streets located within townsites shall not be less than 50 ft. wide (old law 100 ft.) except those now existing of a lesser width. Amendment also provides that such highways may be as wide as required in the discretion of the public authority in charge thereof.

Kansas.—Amends Section 11, Chapter 225, Laws 1929 (Section 68-410, 1931 Supplement to Revised Statutes) to provide that in letting contracts for construction, improvement and maintenance of state highways, no contract shall be awarded to a contractor unless he has established a permanent office in the state so that service can be had and taxes collected. Further provides that the contractor or contractors or subcontractor or subcontractors shall pay all indebtedness incurred for supplies, material or labor furnished, including gasoline, lubricating oils, fuel oils, greases, etc.

About Roadway Stability *Using Calcium Chloride*

By H. F. CLEMMER
Engineer of Materials, District of Columbia

THAT we are now entering an era of unprecedented low-cost improvement of secondary roads is very evident, according to Prof. Ben H. Petty, who believes that the peak has been reached in improvement programs concentrated on main state highways. During the past ten years a net work of high type pavements has become a reality. With this development has come an appreciation of the value of improved roadways, which has created a demand for the improvement of our secondary roads. These latter roads require, in general, only the so-called "low-cost" type of improvement.

With the study as to the best methods of treatment for these roads, and from the study of the service records of our high type pavements, the importance of obtaining a thorough knowledge of the subgrade foundation conditions as they exist, has developed. Soil experts, particularly those connected with the Federal bureaus, are putting forth every effort to learn the best methods of treatment for various types of soil to obtain the maximum stability of subgrade.

In some states, where traffic did not warrant a costly road and finances were not available, roadways, which have proven entirely adequate for the requirements of the existing conditions, have been constructed and maintained at a very low cost. One of the most interesting types has been the sand-clay roads in the South. Where proper care and study has been exercised in the construction of these roads, the surface developed has been satisfactory.

The research engineers of the U. S. Bureau of Public Roads, in cooperation with a number of state highway departments, have recently developed fundamental facts regarding the laws controlling the stability of low cost road surfaces.

So important has become this problem of soil stabilization, and the studies referred to above have progressed so satisfactorily, that most of the state highway departments, many of which now include a special soils organization, are applying the principles that have been determined, to obtain the maximum benefit in road construction according to their local conditions.

Roadbed Stability.—The basic requirements for stability in low cost road construction, as suggested by the studies of the Bureau of Public Roads, are a graded granular material and a binder. It is the granular material or mineral aggregate which furnishes the structural strength of the road slab, and also the hardness of surface to resist the abrasive action of traffic. The binder consists of two parts: an inert filler and a cohesive cement. The silt particles which have practically no cohesive properties and are not apt to expand or shrink in appreciable amounts due to moisture changes, and which by themselves have little or no stability in the presence of water, form the filler in soil road slabs. In this capacity silt performs the very important function of "packing" in the voids between the larger sand grains and preventing the rocking action or movement of these grains, which is destructive to the stability of the slab. The finer clay particles and the colloids, the very finest material, furnish the cement or "glue" to bind the sand or gravel grains, properly choked by the inert silt particles, into a stable wear resisting untreated soil road surface.

Function of Soil "Glue."—The function of the sand particles and the silt filler is the same, regardless of the type of cementing agent and is well understood by the road building fraternity. The manner in which the soil "glue" functions, however, may not be so generally understood, because it is the moisture films between the minute soil particles and not the particles themselves which comprise the true binder. Instead, therefore, of the soil "glue" having a distinct degree of cohesion as is our general conception of a glue or cement, it may be enormously high or practically zero, depending upon the extent to which the soil is filled with moisture.

As suggested by C. A. Hogentogler in his reports presented to the Highway Research Board, the cohesive force of water, which is generally referred to as surface tension, may reach unbelievable values. These forces may be understood when it is considered that moisture in trees will rise to 300 to 400 feet in height. The force needed to hold this column of water is furnished by the surface tension and would amount to as much as 170 lb. sq. in. A further illustration is the automobile racing course at Daytona Beach which accommodates speeds requiring the highest stability and abrasive resistance. This course consists of perfectly cohesion-less fine grained particles cemented together temporarily by surface tension furnished by an interstitial sea water film.

From the foregoing discussion the importance of maintaining moisture in the soil may be realized. Should the clay or binding medium be allowed to dry out, the surface tension between the individual particles is destroyed. However, if material such as calcium chloride, possessing deliquescent properties, is properly incorporated with the binder it will serve to supply sufficient moisture to maintain this cohesive ability of the binder and thus aid in maintaining a road of maximum stability.

Experimental Work.—Investigations are being made of both physical and chemical admixtures and the manipulation required to change clay, silt, or sand subgrade into semi-solid constant volume road slabs, capable of accommodating heavy traffic when surface treated or covered with relatively thin flexible wearing courses. The problem is to create a subgrade which will not soften up in the presence of moisture, that is, one that will not readily absorb moisture.

Two years ago the Highway Research Board of the National Research Council, realizing the importance of this problem and interested in the value of calcium chloride in the treatment of gravel roads, established a committee of engineers to study the use of this material for highway construction and maintenance.

Two research projects were started under the direction of this organization in the summer of 1931; one project in South Carolina on a sand-clay road and another in

Missouri on a gravel road. The results of experiments conducted on these projects show that the calcium chloride treated sand-clay soils did not lose moisture at as rapid a rate as the untreated soils of the same character.

A check made in the Missouri investigation, to determine the loss of road material by comparing the dust collected on treated and untreated sections, indicated that fifty per cent less dust and fine material was collected from sections treated with calcium chloride.

Study during the past year, 1932, was continued on these projects as well as on a new project in Nebraska. In order to determine the best method of using calcium chloride, attention was given to the study to determine what reactions took place when calcium chloride was used for maintenance, and what chemical reactions the calcium chloride might have with the soil, as well as the effect of rainfall, and the effect of maintenance manipulation.

It was found that the loss of calcium chloride due to chemical reaction with the soil, or base-exchange, is dependent on the chemical composition and the degree of acidity of the soil. The fact is established that an exchange of bases may take place when a soil is treated with calcium chloride solution; that is, part of the calcium is absorbed by the soil and is replaced by an equal amount of some other base. This chemical exchange, however, is the least influential of the three factors studied, but it is mentioned because in some soils it may influence the structural texture in such a manner as to make its effect of particular importance. It does offer the best method for determining the effects of calcium chloride on different soils. At present it appears that this action is usually offset by certain inherent structural characteristics of the soil, which play a more important role in the retention of calcium chloride. This soil reaction makes subsequent applications of more value and likewise reduces the amount of calcium chloride necessary to produce maximum results, inasmuch as it is believed the base-exchange action reaches equilibrium, and the dissipation due to this cause is minimized.

Losses of Material.—The loss due to the washing out effect of rains depends on the type of rains, the permeability and texture of the soil. The maximum loss from this cause would occur when a heavy rain immediately follows application.

The loss due to continued daily maintenance was, however, the most important factor considered. It was found that sections maintained only immediately after a heavy rain or when absolutely necessary, remained in better condition, with less dust, than sections receiving daily maintenance, carrying comparative amounts of traffic. These results show that more value is derived from the use of calcium chloride when regular maintenance is carried on *only* during or immediately following rains.

Action Following Rains.—An explanation of the action of calcium chloride, when used in the treatment of gravel roads, during and following rains is of interest. During prolonged dry spells the solution of calcium chloride present in the soil due to previous application is drawn to the surface. When a rain occurs, the first water absorbed serves to carry this solution below the surface. When the surface material becomes saturated subsequent superfluous rainfall is shed into the ditches. Following the rainfall, evaporation of the surface water takes place. As the moisture in the top layer of the road evaporates it is replaced by the solution of calcium chloride, which has been stored below the surface during the rain. This solution is brought to the top by the capillary action of the soil. Evaporation takes place until a concentration is reached at which the calcium chloride solution will no longer lose moisture under the existing humidity and temperature conditions.

Maintenance Manipulation.—From this discussion it can be seen that if maintenance manipulation is carried on while the calcium chloride solution is near the surface, the material is dissipated; however, if manipulation is carried on during or immediately after a rain, when the calcium chloride solution is some depth below the surface, the road surface may be put in the best possible condition without loss.

Investigators interested in this problem are now studying the many beneficial effects of calcium chloride towards improvement of the condition of the soil for a satisfactory road surface, and they consider the alleviation of the dust nuisance, which is in reality a dangerous factor, only as one of the added benefits.

One value of calcium chloride is its ability to flocculate soil, that is, to cause small particles to group together into larger ones to produce a more permeable soil. This effect is important in reducing the destructive frost action. The open or permeable soil does not hold the moisture, which when freezing creates expansive forces.

Application.—Maintenance engineers regularly using calcium chloride do not believe it should be applied at any specific rate, but rather depending upon the amount of traffic carried by the road. The following table shows typical practice under general conditions:

100 to 200 vehicles per day	1 lb./sq. yd.
200 to 500 vehicles per day	1½ lb./sq. yd.
500 to 1000 vehicles per day	2 lb./sq. yd.
1000 and up vehicles per day	2½ lb./sq. yd.

The best practice of applying calcium chloride is to make several applications. For example, should the road require 1½ lb. per sq. yd., it would be advisable to make one application of 1 lb. per sq. yd. and follow with a second application of ½ lb. at an interval of approximately six weeks, depending upon the prevailing weather conditions.

A summary recently offered by the Maintenance Committee of the American Road Builders' Association* presents the following outline for the proper use of calcium chloride on a gravel road.

(1) Remove oversize material.
(2) Add to the gravel the constituents it lacks, either sand or clay.
(3) Scarify the surface and thoroughly mix all material added.
(4) Maintain not more than ½ in. to the foot of crown.
(5) Removal of all cover and apply calcium chloride.
(6) Blade carefully after each rain and at such other times as the surface of the roadway demands it.
(7) Patch any holes with the same material as used in the entire surface.
(8) Use heavy equipment for spring work.

Conditions demanding heavier application of calcium chloride are long dry spells, heavy traffic, low clay content, recent heavy resurfacing, no shaded portions, heavy wearing cushion and dead material. Conditions favorable for lighter applications are frequent rains, light traffic, heavy clay content and shade.

The item No. 2, "Add to the gravel the constituents it lacks, either sand or clay" is one of the most important of the requirements in the outline and is being given consideration in studies of stabilization of soils. To develop a hard durable surface, the amount and type of cementing meduim which will produce maximum stability must be used. The research work carried on by the

*Convention Proceedings, 1930, page 705.

Bureau of Public Roads has developed tests which will offer practical information as to the best treatment of soils to obtain maximum stability.

Stability of a soil is dependent on both the cohesion and the internal friction which the particles exhibit. In general, clay, and colloidal material supply the cohesion necessary for stability while the internal friction is furnished by the sand.

Obtaining and Measuring Stability.—The amount of binder required to furnish stable mixtures depends upon the expansive properties of the binder. Binders which are only slightly expansive may be used in an amount sufficient to fill the pores of the sand almost completely. As the expansive properties of the binder increase, the amount used without danger of unseating the sand grains must of necessity become less. Of two soils whose tendency to shrink or expand are equal, the one having the greater amount of cohesion should be the better binder; of two soils having equal cohesion, that having the less tendency to shrink or expand should be the better binder, since a greater amount of it can be used than of a more expansive soil.

With a satisfactory gradation of sand and gravel particles to form mechanical interlocking and with enough clay to bind the particles together, but not sufficient to separate the particles so as to admit of excessive moisture which would make the clay a lubricant rather than a binding medium, an entirely stable combination may be obtained. It is necessary that the clay be moist at all times so as to be expanded sufficiently to press the particles in place and bind them solidly together. This moisture is maintained by the addition of the proper amount of calcium chloride. As stated, the Bureau of Public Roads has developed tests which are simple of performance and offer valuable information as to what treatment a soil requires to obtain maximum stability.

Apparatus which measures directly the drainage and capillary properties of a soil has been described by C. A. Hogentogler of the Bureau of Public Roads at the recent meeting of the Highway Research Board. At the present time apparatus of a similar type, which also includes a method for measuring stability, is being developed for field use. Such an apparatus will prove of particular value as it will eliminate extended programs of study or research which have heretofore been necessary.

When due consideration is given the results which may be obtained by proper construction, and the saving in maintenance which will result from proper manipulation of the road surface, the study as to the more satisfactory maintenance of roads is justified; rather than to follow the common practice of using any available material regardless of existing conditions and by the application of a deliquescent product endeavor to keep the road material from being dissipated by the wind and traffic. In other words, investigate the available coarse and fine material and combine them so as to secure in fact a "concrete" road, but one in which the cementing medium is clay or some other binding material in place of portland cement.

Calcium chloride will save enough in material replacement to pay for its use; and though the proper study and combination of materials will incur some original expenditure the saving in maintenance brought about by this consideration will more than pay this cost and the public will be provided with a smooth and dustless road surface.

(Acknowledgment—The foregoing is an abstract of a paper presented at the 1933 Road School at Purdue University.)

Half Billion in Gas Taxes in 1932

State gasoline and motor fuel taxes and licenses for the sale of gasoline yielded a total revenue of more than $514,000,000 in 1932 according to reports collected from state authorities by the Bureau of Public Roads, U. S. Department of Agriculture. More than 14 billion gallons furnished power for motor vehicles. The tax was at an average rate of 3.6 ct. per gallon. Consumption of gasoline declined 7.5 per cent from the previous year. Delaware and Maryland were the only states reporting increased consumption.

The total revenue was allocated as follows: To state highways, $301,788,231; to local roads, $94,073,954; to state and county road bond payments, $50,726,362; to city streets, $16,776,050; to costs of collection and administration, $2,832,820; and to other than highway purposes, $47,941,483.

The gasoline tax revenue by states were as follows:

State	Total tax receipts (refunds deducted)	Tax rate on Dec 31, cents	Net gallons taxed	Percentage of increase or decrease in consumption from 1931
Alabama	$ 7,001,088	6	136,421,624	—16.1
Arizona	2,900,920	5	58,004,441	—10.4
Arkansas	5,164,976	6	86,082,940	—22.2
California	36,128,854	3	1,204,295,149	— 9.4
Colorado	5.469,220	4	136,730,489	—12.6
Connecticut	4,732,512	2	234,229,379	— 0.9
Delaware	1,090,150	3	36,338,331	+ 1.7
Florida	14,531,707	7	207,268,239	—11.8
Georgia	11,938,809	6	198,980,154	—10.3
Idaho	2,287,295	5	45,554,550	—12.3
Illinois	28,754,051	3	958,468,356	— 1.1
Indiana	16,739,604	4	418,489,040	— 7.2
Iowa	8,970,137	3	299,004,568	—17.9
Kansas	7,420,495	3	247,349,852	— 8.1
Kentucky	8,206,105	5	164,057,785	— 6.9
Louisiana	8,300,722	5	166,014,436	—11.7
Maine	4,254,376	4	105,167,540	— 4.0
Maryland	7,500,232	4	187,505,794	+ 0.9
Massachusetts	16,519,278	3	550,642,607	— 1.4
Michigan	20,460,611	3	681,044,263	— 6.4
Minnesota	10,000,557	3	333,351,913	— 9.7
Mississippi	5,843,750	6	96,732,445	—16.4
Missouri	8,949,693	2	447,484,670	— 2.8
Montana	2,690,156	5	53,803,120	—10.9
Nebraska	7,809,465	4	195,236,623	—14.1
Nevada	727,117	4	18,177,920	— 6.5
New Hampshire	2,638,841	4	65,971,040	— 0.7
New Jersey	16,674,671	3	553,914,175	— 3.0
New Mexico	2,210,502	5	43,845,055	—17.7
New York	42,580,593	3	1,485,127,929	— 2.8
North Carolina	13,907,377	6	231,727,434	— 7.2
North Dakota	1,837,151	3	61,190,398	— 9.6
Ohio	34,269,179	4	856,729,484	—12.9
Oklahoma	9,682,442	4	241,527,434	— 4.3
Oregon	5,591,175	4	[1]140,066,134	— 9.7
Pennsylvania	30,800,915	3	1,009,663,827	— 6.7
Rhode Island	1,857,711	2	92,701,236	— 2.0
South Carolina	6,224,927	6	103,748,781	—14.1
South Dakota	2,963,348	4	74,083,694	—12.7
Tennessee	12,185,360	7	174,076,575	—15.8
Texas	27,063,758	4	676,593,941	—11.3
Utah	2,172,669	4	54,297,788	—10.0
Vermont	1,874,648	4	46,866,212	— 4.7
Virginia	10,809,600	5	216,191,996	— 5.6
Washington	11,046,510	5	220,930,195	— 9.7
West Virginia	4,949,400	4	123,544,775	— 8.3
Wisconsin	14,948,420	4	373,710,495	—13.4
Wyoming	1,418,145	4	35,453,612	—10.6
District of Col	2,039,678	2	101,774,858	+17.9
Total	$514,138,900		14,250,173,296	— 7.5

[1]Includes approximately 2,294,022 gallons of "Distillate" at 3½-cent tax.

Promoting Safety in HIGHWAY CONSTRUCTION

By HARRY D. IMMEL
Safety Executive, Pennsylvania Department of Highways

THE propensity of the modern public highway to produce accidents does not begin with its opening to traffic. It begins back of that—begins in fact with the very first steps in the highway's construction.

Years of responsibility for promotion of industrial safety in a great industrial state, as Director of the Bureau of Inspection of the Pennsylvania Department of Labor and Industry, sufficiently impressed me with the difficulties peculiar to application of safety to any branch of construction. Common labor, recruited job by job, does not lend itself readily to that well-disciplined control and high morale that discourage accidents. When there is coupled to this the necessarily wide distribution of labor in a highway construction and maintenance program covering an area of 45,126 square miles—which is the field of activity of the Pennsylvania Department of Highways—the problem becomes much more complicated.

The adaption of our highway program in Pennsylvania to the widest possible offering of work-relief in the present unemployment situation admittedly is not a normal requirement. Probably it never will be met with again in the present generation. Certainly those of us responsible for promotion of safety in highway construction and maintenance by governmental agencies fervently hope that it will not. Out of it grows a condition which presents the very maximum in numbers of difficulties in accident control, and because many states and even smaller political sub-divisions are adapting their road programs to work-relief, all of us should contribute our respective shares of experience in methods of dealing with it.

Taking for granted full managerial support, supervisory responsibility and strict enforcement of safety regulations become the most important factors in the safety program of a state highway organization. They are the factors upon which our dependence must be placed almost entirely when working with a large percentage of temporary laborers. I do not mean to discount to any degree the importance of mechanical safeguards. They must be at the very foundation of any industrial safety program.

Department Purchases 24,000 Pairs Safety Goggles.—Before winter restricted our operations on Pennsylvania highways in late December we had 55,000 laborers engaged at one time. Hand knapping of native stone and of slag to provide the base for rural roads afforded most of this employment. There naturally was an unusually high exposure to eye accidents. To meet this situation the department has purchased 24,000 pairs of safety goggles. I doubt if any other industrial organization in the country uses as many.

Mechanical adjuncts to safety are effective, however, only if they are constantly used. Strict enforcement of regulations is necessary to assure the wearing of goggles after they are provided. The worker on Pennsylvania state highways who fails to wear goggles when an eye hazard is present is dismissed immediately. If his foreman has been to any extent at fault through failure to enforce this or any other safety measure he also is dismissed or suspended. This may appear at first glance to be drastic action, but we have found that there dare be no compromise with negligence when a safety program is being applied in a widely extended organization. Despite all our efforts, two eyes were lost last year because workers deliberately disregarded our goggles regulations.

Device Developed in Driving Posts.—One safety device developed by an employe of the Pennsylvania Department of Highways is worthy of special mention. This device, a cast-steel driver for steel snow fence posts and sign posts, was brought forth as a substitute for driving these posts with sledges, which had proved to be a dangerous as well as a destructive practice. In the sledging method a small steel cap is fitted over the top of the post and the post is then held in position by one worker while another drives it to the required depth with a sledge. It was found that the caps soon mushroomed and often were broken in use, the operation presenting a constant eye hazard as well as the possibility of injury from a misdirected blow. Careless workmen frequently drove the posts without using the cap and in consequence the tops of the posts would be so badly battered that they could not be used again unless the battered ends were cut off.

Post Driver Developed by Pennsylvania Department of Highways Eliminates Hazards of Sledging

The driver developed to replace sledging fits as a sleeve over the capped post. It weighs about 60 lb. and is provided with two handles. It is used most effectively by two men, who, with a few blows produced by lifting and lowering the device, can set a post without damage to the post or injury to themselves. Aside from the safety factor, a typical report from the field says of the driver, "It speeds up the work and saves the posts."

Safety Education Worth While.—We consider safety education worth all the effort that can be given to it. Our supervisory personnel and our permanent laboring force constantly are being taught safety. We consider a membership in the National Safety Council, with the posters and other propaganda it provides, to be indispensable. We constantly are developing, out of our own accident experience, material from which to shape precaution measures, and, in the short period of existence of our safety organization, have issued one photographic poster to the field displaying some of our safety goggles that saved eyes.

Working as we are at high pressure on the most intensive road construction program ever undertaken by any state, the time available for foremen's meetings and other gatherings for safety discussion is extremely limited. We do, however, call together groups for this purpose whenever possible, and have found time for some safety discussion in meetings called primarily to discuss construction and maintenance programs. Regardless of this merging of discussions, safety is not placed second to anything. We merely in this latter instance mould a standard organization practice to safety advantage. Use of expediency produces the greatest safety.

First Aid Instructors Trained.—With groups working in isolated places, often remote from physicians and hospitals, the importance of first aid cannot be over-estimated. The briefest examination of the accident records of the Pennsylvania Department of Highways will impress the trained observer with the disproportionate extent of severity. Of course, unless intelligently applied, first aid had better be left alone. The Pennsylvania Department of Highways has solved this problem. Through arrangement with the American Red Cross the services of Dr. W. J. Fenton, an expert instructor, were obtained by the department to conduct a 30-hour course to develop a group of first aid instructors in the department. The members of this class were selected with great care, one from each of our twelve field districts, one from our central mechanical unit, and several more from the Central Office safety organization, including our safety engineer. Most of these men are college graduates. They occupy positions of responsibility in the department and their teaching will command the respect of those to whom they transmit the instruction they have received. I speak of this in the future tense because the training of these instructors has been just completed. Red Cross officials tell us that it is the first undertaking of this scope by any state department in the country. The Tennessee Highway Department has undertaken the same thing on a somewhat smaller scale.

The men who formed this instructors' class will become the backbone of our safety organization in the field. Their home offices are so located that their knowledge can be applied with the greatest facility. They will teach intelligent application of first aid to every foreman and caretaker, these being the supervisory individuals in immediate touch with our laboring forces. Along with first aid they will teach safety. When these men were assembled in Harrisburg for their first aid instruction they were given a series of safety talks by experts. Their training as safety instructors will be extended through contacts with community safety councils as well as other means.

First aid kits have been supplied to every field unit and it is expected that, when the training of our supervisory force has been completed, accident severity, which mainly has been due to neglect of minor injuries, will be reduced quite measurably. Nevertheless, we are stressing the fact that nothing will take the place of a physician's professional skill if the injury is at all severe, and that in all such cases the accident victim must receive medical attention without delay.

Temporary Laborers Have Their Troubles.—We have found the temporary employes obtained under the state's work-relief plan to be especially prone to minor injuries, which in the aggregate involve an inordinate amount of compensation and loss of time. Ivy poisoning, while usually not serious, often incapacitates a worker. The gathering of native stone by hand from fields, woods, and fence rows, and the brushing out of rural roads, frequently brings road workers into contact with poison ivy. In 1931, with an average of 13,000 employes, we had 181 cases of ivy poisoning, involving 1,072 lost days. Last year, with an average working force of about 29,000 employes 310 cases were reported for the year, with 2,000 lost days. Teaching our workers to apply soap and water promptly after exposure to poison ivy and simple first aid treatment, were responsible in 1932 for a decrease of about 12 per cent in loss of time from ivy poisoning. Actually a full summer season of rural road construction last year as compared with only a brief period of similar work in warm weather in 1931 increased our poison ivy exposure about 400 per cent.

What we most expect from our first aid teaching, of course, is some additional consideration of safety. As all safety engineers know, first aid training develops safety-mindedness. We are asking each foreman and caretaker to devote a few minutes of safety instruction to each new group of employes with whom he takes the field, this instruction to be given before they take a tool in hand.

Accident Records Assembled.—As a safety incentive, and as the only businesslike method of procedure, the Pennsylvania Department of Highways has given as much attention to assembling its accident records and transmitting them to the field as does the highly organized private industrial concern. We record accident frequency and severity by field units in the fairest method possible and present the standing of these units to encourage the competitive spirit in accident reduction.

In addition to the standard accident report for each injury, which is required in Pennsylvania under the Compensation Act, we have developed a simple foreman's report form. We require this of every foreman and caretaker for every accident that occurs to a member of his force. This report calls for a brief description of the accident, the foreman's opinion of who was responsible, his recommendations to prevent recurrence, and a statement whether first aid was administered. Of course, to expect that the foreman will admit personal responsibility for an accident to one of his workers is a bit unreasonable. But we are certain that the foreman who prepares one of these reports, one copy of which goes to his superintendent's office and the other to the Central Office, will be impressed with the peace of mind that goes with avoiding the necessity of making any such report. This report might be termed just another bit of important safety psychology.

Use of Accident Reports.—Nevertheless there is a very practical use that can be made and should be made of all accident reports. We believe that our own accident experience will serve as the very best guide to safety

effort. Therefore every accident is analyzed carefully from the report, and the factual data thus obtained are employed in the development of new safety regulations and in our program of safety education. Special investigation is made of those accidents which seem to warrant it. Distribution of circulars describing certain of our accidents and the manner in which they could have been avoided brings excellent results.

Two years ago the Pennsylvania Department of Highways had no safety organization, and accident prevention was receiving scarcely passing attention. Systematic safety effort in the department began only a little more than a year ago, when Secretary Sam S. Lewis, head of the department, employed a safety engineer. As might have been expected, the new safety engineer had rough sledding for a while, set down as he was in the midst of a great organization that was so busy building and maintaining roads that it felt that it had no time to devote to "fads." As Secretary Lewis said recently, in addressing the first aid instructors' class, "When this safety business was first put up to me I regarded it as pretty much of a joke. I know different now and I am here to say that every member of my big organization must contribute his full share to prevent accidents." With characteristic energy and determination, Secretary Lewis, as soon as he realized the importance of safety work, gave his whole-hearted support to the undertaking.

Set-Up of the Safety Organization.—Today the safety organization of the Pennsylvania Department of Highways has been perfected in a simplicity which we have no hesitation in recommending as a satisfactory set-up for a large governmental agency engaged in highway work. My own position is that of safety executive in close contact with the head of the department and his other chief executive assistants. Under our organization the safety executive also heads our traffic safety program, which aims to develop physical highway conditions that will contribute to the safety of motorists.

That portion of our safety organization which altogether has to do with the safety of the worker includes a trained safety engineer and a statistician assistant in the Central Office, together with the field representatives already referred to, who are located in each district and in the mechanical unit. Along with this set-up it is well understood that enforcement of safety regulations and application of safety principles is a supervisory function to which every supervisory employe is required to contribute his full share.

The Pennsylvania Department of Highways last year paid a compensation insurance premium of close to $450,000. In 1931 our premium was $324,766. Compensation insurance is placed with the State Workmen's Insurance Fund which is a compensation insurance company conducted by the state on a non-profit basis. Our compensation costs in 1931 were $251,640. Anyone familiar with the overhead costs of conducting a compensation insurance company knows that we were not what would have been considered a good risk in 1931 in spite of the considerable margin between premium and claims. It will be a proud day for our safety organization when we can recommend to the secretary self-insurance as an additional means of cashing in on our investment in safety.

As a matter of fact we already can claim a substantial balance on the right side of the ledger. Our compensation costs for eye accidents in 1931 were $28,000. For 1932 they should not total more than this amount in spite of the fact that exposure was increased enormously and our compensation outlay for this type of accident at the 1931 rate would have been at least $100,000.

In a period of two months last fall we had 40 pairs

EIGHT THOUSAND DOLLARS WORTH OF GOGGLES !
ONLY FOUR PAIRS
BUT
EACH SAVED AN EYE OF A WORKER ON
PENNSYLVANIA STATE HIGHWAYS
AND THE COMPENSATION COST OF A LOST
EYE AVERAGES $2,000
ALL THE MONEY IN THE WORLD WILL NOT REPLACE A LOST EYE
WEAR YOUR GOGGLES
SAVE YOUR EYES

Goggles That Saved Eyes. A Safety Poster Prepared by Pennsylvania Department of Highways

of goggles returned from the field to the Central Office for replacement of shattered lenses. Every broken lens represents an eye injury avoided. Some of the lenses were so badly shattered that loss of sight would have been certain had not goggles been worn. The average compensation cost for an eye loss in Pennsylvania is about $2,000.

Four eyes were lost in 1932 from conditions that goggles could not have controlled. One worker with an infected finger rubbed his eye and infected the eye; another had an eye directly infected by an injury sustained when he tried to remove a bit of dust. One eye loss resulted from an automobile collision, and one from an explosion of dynamite. Our slogan for 1933 is "No eye losses."

An outlay of about $7,000 to equip trucks with self-starters was authorized last year. That it was a sound, safety investment is shown plainly by the fact that we had been averaging about 100 accidents annually from "kick-backs." The average cost of these accidents was $86.57 each. Henceforth hand-cranked trucks are taboo with the Pennsylvania Department of Highways.

Our 1932 accident record, compiled as well as it can be at this time, shows a reduction of about 5 per cent in frequency and 15 per cent in severity, as compared with 1931. We recorded 17 fatalities in 1931 and 13 in 1932. In considering all of the statistics given it must be borne in mind that our greatly increased exposure really began when work was started on our 20,000-mile rural road construction program in August, 1931.

As previously explained, our 1932 accident exposure under the work-relief plan of temporary employment was a safety engineer's nightmare. There is absolutely no way of fairly comparing our 1932 record under these conditions with anything that went before. We hope that industrial improvement will be so marked in 1933 that it shall be just as impossible to compare last year's state highway employment conditions with this year's.

Will Blind Samson Bring the House Down?

LEGAL encroachment upon the economic freedom of the oil and automotive industries, through excessive taxation and the restriction of their normal functions, threatens to reduce the future profitability and worth of their assets. The magnitude and rapidity of growth of the movements against these industries warrant the thoughtful consideration and collective defensive action of their security holders. Moreover, the implications which arise from the strangulation of these allied industries portend such profound changes in the principles upon which American economic progress has been founded as to command the attention and merit the unbiased judgment of security holders in all industries and the people generally. To discriminate against the chief product of the oil industry by levying on it taxes which are excessively disproportionate to those placed on non-petroleum products and to obstruct the normal growth and hinder the operations of the highway transport industry for the benefit of other industries is to perpetrate economic injustice. Those who benefit from it in one season may be the victims of it in another. How does it affect the interest of security holders and others?

By the discriminatory taxation of gasoline and by placing limitations upon the use of the highways by one of the best customers of the oil industry, the latter is twice hurt. The excessive taxation and restriction of the economic use of a product constitute at once the subtlest and most potent forms of competition. Persons accustomed to think only of competition as between units in the same industry overlook the existence of competition on a larger scale, namely competition between entire industries for a share of the consumer's dollar. Even though all of an excise is collected from the consumer by the producer, the latter, nevertheless, is disadvantaged relative to producers of untaxed commodities. Consider the case of an industry whose product has been permitted to compete on equal terms with the products of other industries. The consumer's satisfaction in the use of this product has led him to willingness to spend a portion of his income for it. Collectively, consumers' requirements constitute "demand." The total demand for the product has necessitated the creation of plant and equipment for its production and distribution. Suppose tax legislation is enacted whereby the total cost of the product to the consumer is doubled. A limited income requires that purchases be curtailed to the extent of the tax. Conceive, first, the effect upon the volume of demand for the commodity; and second, the effect of the reduced throughput upon the profitability of the plant which had been provided to supply it. Moreover, the consumer's restricted consumption of the product may create a social problem and perhaps also a political one. Prohibition of the use of a commodity may be accomplished by tax legislation.

Sometimes the public interest may require the legalistic restriction of the use of a product or of a facility of service. The moon provides a notable illustration. But is advocacy of restraint of the operations of the oil and automotive industries warranted on the grounds of public morality? If the normal functions of these industries do not involve the public morals, what grounds can be provided for discriminatory tax and other measures against them?

Whether an affirmative answer to the preceding question can be found will depend upon the logic with which one surveys the economic consequences of placing upon any product greater governmental burdens in the form of taxation than are its proportionate share; and whether American economic life has reached a stage wherein the handicapping of an industry should be affected for the advantage of a competitive industry. Discrimination cannot be justified by the facts that the industry which has been the subject of these legislative enactments has grown lustily since the war; nor that the tax levied upon it may be collected easily; nor that the restriction of its operations may cause only retardation of its growth and not actual decline. The question for each citizen to answer is whether the American principle of freedom for constructive economic development is to continue operative. Is competition between industries wholesome for American economic life? Heretofore the economic interests of individuals and groups were protected by the practice of fair play and their own alertness. Are these processes to give way to protection by legislation? Consider some facts and the implications thereof.

The motor vehicle and gasoline seemingly have shown their ability to contribute vast sums to the public treasury. In 1932, the combined motor registration fees, state gasoline taxes, and miscellaneous automotive taxes totaled approximately $1,100,000,000. Regardless of the enormity of this and similar but proportionately smaller payments made for prior years, few automotive taxpayers have complained. Probably such taxes have been paid less unwillingly than any large-scale direct taxes recorded in the history of taxation because taxpayers could perceive and enjoy the benefits derived from their payments. Until recent years, substantially the whole of automotive taxes was expended to provide new highways and for improvements of old highways; the motorist's range of travel was expanded; the country was brought nearer the city; real estate values were improved; opportunities for recreation were enlarged; costs of personal and property transportation were reduced. The fact that many payers of automotive taxes paid more than the cost of the limited mileage of densely traveled highways used by them, as in the urban centers, did not cause undue concern. Moreover, since 1920, as the average state gasoline tax rose steadily from 0.08c per gallon to 3.75c per gallon, the petroleum industry successively reduced its costs and selling prices to the consumer so that in the last two years the selling price, including the high tax, has been substantially less than it was in taxless days. The growth of the demand for gasoline, even during 1930 and 1931, may be explained in part by this fact. Seemingly, the oil industry has reached the limit of its ability further substantially to reduce the price of gasoline; notwithstanding this probability, the taxing authorities propose to continue the upward trend of gasoline taxes.

The simplicity and ease with which taxes could be levied and collected on motor vehicles and gasoline have led legislators everywhere to ask: Why not tax gasoline for the support generally of government? Indeed, dur-

ing the past two years action on this question has led to substantial increases in state gasoline tax rates. Moreover, *in the year just closed approximately* $120,000,000 *of gasoline tax revenues have been diverted to non-highway uses.*

It may be asked: Because all tax receipts are derivable from the people, what difference does it make whether they come from one form of taxation or another? When this question is answered as it has been answered in the Congress and in certain state legislatures and local governments, there results the type of economic injustice which has been discussed briefly. What would be the consequences of carrying to its logical conclusion the answer of the Congress to the immediately preceding question? Obviously, concentration rather than diversification of taxation. Ponder the effect of applying the principle of concentration to the estates of decedents, which in recent years have had annually a gross value approximating $4,000,000,000; or a tax on the approximately 80 trillions of kilowatt hours of electricity distributed annually; or a tax on savings in the form of bank deposits, building and loan and insurance assets, totaling $75,000,000,000. In the current movement towards tax discrimination against gasoline there is involved the whole problem of taxation with its opposing theories of concentration and diversification; and underlying all, the need for maintaining economic justice.

To provide equity in taxation is an age-old problem. The gasoline tax, created for the purpose of financing highways, was a worthy experiment in taxation. It brought the burden of tax-payments and the benefits of their expenditure into conjunction. The gasoline taxpayer, who, incidentally, also pays all of the kinds of taxes paid by non-users of gasoline, was willing to be taxed for his roads. But how much further should he be taxed through his consumption of gasoline? The experiment in taxation to relate the burden and the benefit will be frustrated by an extension of gasoline taxation to provide the manifold general services of government. General Fund applications of gasoline tax revenues are foreign to the purpose and the principle of the tax and place upon the product an unequal burden which upsets the economic balance between commodities which compete for shares of the consumer's dollar.

Concentration of taxation was effected and the disregard of the need for maintaining economic balance between commodities was evidenced by the action of the Congress in placing upon gasoline a tax of 1c per gallon, surmounting the now average state tax of 3¾c per gallon. In terms of the wholesale price of gasoline, a cent a gallon is equal to more than 20 per cent of its average wholesale price. The same Congress placed a tax on cereal beverages of only 1¼ per cent; on candy and chewing-gum of only 2 per cent; on electrical energy of only 3 per cent; on telegraph messages, tooth pastes, radio receiving sets, and mechanical refrigerators of only 5 per cent; on cosmetics, cameras, firearms, sporting goods, furs, and jewelry of only 10 per cent. Why the discrimination; and why should any product be disadvantaged through taxation in its competition for the consumer's dollar? Parenthetically, the same law included a levy on lubricating oils approximating 30 per cent of the wholesale price, while the highest rate of tax on non-petroleum products was 10 per cent. It is not to be overlooked that these petroleum products are not deterrents to high public morality but rather contribute subtantially to the attainment and maintenance of a high standard of living.

Undoubtedly some of the legislative proposals to tax and restrict the oil and automotive industries originated with legislators' concepts of the ease with which the tax can be levied and collected. Perhaps a majority of the proposals have been incited by the advocates for restriction of these industries who have expressed repeatedly the opinion that the latter through taxation have not provided the cost and maintenance of highways. Indeed, the railroads go so far as to allege that they have been penalized by taxation for the purpose of subsidizing the motor vehicle and especially the motor truck. This is a specious argument, apparently supportable by readily available data which have been compiled by the railroads and given wide publicity.

The facts are too numerous and their manifold interrelations too complex and too full of significance to permit the portrayal of a comprehensive and impartial presentation of the situation by the railroads' simple line chart. Nor does space here permit expression of more than a mere suggestion of some highly pertinent facts.

A very large percentage of all automotive taxes is collected on vehicles whose travel is in, and, or, quite adjacent to, urban centers. This fact may be illustrated by consideration of automotive usage in that part of metropolitan New York City which is wholly in New York State. Herein, according to competent estimators, upwards of 40 per cent of the gasoline consumption and automotive operation for the entire state of New York occurs. Furthermore, traffic studies provide facts which indicate that there are roads leading out of New York, Philadelphia, Chicago, Los Angeles, and other cities whose annual maintenance, depreciation and amortization charges are equaled by one month's gasoline taxes accruing thereon. The results of these studies also suggest that a very large percentage of the annual automotive tax collections is derived from the usage of a minor fraction of the highway system whose entire annual costs thereby are paid 3 to 20 times. It is altogether probable that a large majority of commercial motor vehicles, which operate in these areas of dense traffic, is now being taxed in excess of the costs of the service which they receive—a fine state of inverted subsidy.

Perhaps the preceding recitation of facts and interpretation has indicated clearly that the movement to place higher taxes upon motor vehicles, and particularly upon commercial motor vehicles, is merely part of a larger plan to restrict their operations by any means whatsoever. The broader aspect of this subject will justify some reflection on what follows.

The economic progress of our country and the interest of every citizen are involved in the railroads' attempt to break down constitutional guarantees of equal opportunity to all to prove the worth of their enterprise.

The railroads have exerted great efforts to obtain legislation to restrict the operations of competitive forms of transportation by water, highway, and air. That their experienced lobbyists should have attained some success in the absence of organized opposition was to be expected. Their efforts continue unabated, indeed reinforced. The legislative attack on motor transportation seeks to accomplish two purposes, namely, first, to control the "costs" of motor transport by uneconomic restrictions on the size, load, speed, and mobility of commercial motor vehicles; and second, to fix highway transport's service "charges" to shippers so that motor vehicles cannot offer direct monetary advantage over rail transport. The latter aspect of the matter may serve to illustrate the attitude of the railroads.

A committee composed of railway presidents and

board chairmen, appointed by the Association of Railway Executives, recommended a policy of rate control, applicable both to interstate and intrastate commerce, in these terms:

"As to contract trucks in interstate commerce, to observe minimum rates fixed by regulatory authority and comply with rules and practices applying to rates and service, as may be prescribed by such authority."

The railway officials propose that truck carrying charges shall be made a minimum—that is, that trucks shall not charge for their services less than a rate to be fixed by law. Certain bills sponsored in legislative assemblies have specified that motor charges shall be equal to rail charges. Can the purpose of such rate-fixing be other than to continue the railroads' monopoly of transportation?

Compare the railroads' expressed attitude with the following quotation from the 1932 Annual Report of the Interstate Commerce Commission:

"There is substantially no demand for public regulation of the charges of motor trucks to protect shippers against exorbitant or discriminatory charges. The demand has been chiefly from the railroads, and for the prescription of minimum rather than maximum charges."

The railroad legislative campaign for the restriction of other forms of transportation is charged with implications more serious and far-reaching than the effect of its success on holders of securities of oil, motor and highway transport companies. There is at stake the life of the economic system of fair competition, which has made it possible for our country to achieve the highest level of material comforts and satisfactions known to any people throughout history. Even the holders of railroad securities and persons whose interest in the value of railroad securities is indirect, for example, depositors of savings banks and policy holders of insurance companies, may find in the end that the benefit to accrue from legislative fiat, seemingly in their behalf, may cost more in retarded economic progress than it is worth. In the long run economic rather than uneconomic processes will prevail, but it will be a pity if by arbitrary action the maximum usefulness and economy of the new form of transportation is withheld for a time from the people. Meanwhile much effort of the personnel of transportation systems will be wasted in conceiving, sponsoring, and combating unwise and uneconomic restriction.

There is known only one way to ascertain the usefulness of a new mode of transport. It must be accorded an opportunity to prove its worth unhindered by such uneconomic restrictions as the maintenance of rates above an arbitrary minimum. This does not mean boundless freedom of action. On the contrary, motor transport accepts without complaint its share of all highway costs and submits to all reasonable police regulation for the safety and convenience of its public. But it is still a young industry. There has not been accumulated experience with motor transport which might serve as the basis for the rate and cost regulations which the railroads would force upon it. Indeed, the railroads had nearly 60 years of life before their acts brought them subject to the regulations of the Interstate Commerce Commission. Perhaps in 50 or 60 years of motorized highway transport the need for similar regulations may be established. On this matter the Interstate Commerce Commission said in its 1932 Annual Report:

"Indications are that the number of motor truck operators is very large and that their operations are mostly on a small scale. Regulation which is appropriate and practicable in the case of a comparatively few large, well-organized companies may be quite impracticable in the case of a multitude of individuals or small concerns."

Financially the railroads have not fared so ill. Approximately $5,000,000,000, or 20 per cent of their entire investment, is earned surplus, that is accumulated profit in excess of dividends paid out of earnings. Even during 1931 the railroads earned more than 2 per cent on their entire investment, including a return on their surplus. Indeed, the railroads' rate of return on investment during 1931 exceeded that of most of the large industries of the country. A substantial fraction of the steel industry earned only 0.22 per cent; the petroleum industry lost 0.63 per cent; the sugar producing and refining industry lost 0.12 per cent; the meat packing industry lost 0.57 per cent; the copper and brass industry lost 1.02 per cent; the building and construction industry lost 0.09 per cent and the agricultural implements industry lost 1.12 per cent. Only a few of the large industries of the country surpassed the railroads in rate of earnings, notably the electric, gas and water operating companies, which earned over 7 per cent, the electrical equipment industry, which earned 5.63 per cent, and the chemical industry, 6.24 per cent. Earnings, generally, declined in 1932, probably much less sharply for the railroads, which earned more than 1.3 per cent on investment, than for most lines of industry. The railroads' financial embarrassment arises from their form of capitalization.

The railroads are fighting new and supplementary forms of transportation with energy which advisably might be directed to the economic solution of their problems. According to the Interstate Commerce Commission, only a very small fraction of the freight movement heretofore handled by the railroads has been diverted to highway transport. Motor vehicles have not offered and are not offering the most serious threat to railroad revenues. Of course the effect of the depression has been calamitious. Moreover, the railroads have lost some of their long haul wheat business on account of the decreased demand abroad for American wheat; they have lost some formerly profitable long hauls of hard and soft coal through the displacement of coals by oil and gas; they have lost tother long hauls through the extension of central stations' electric power transmission lines, which have made possible, and are making possible, the decentralization of manufacturing, thus bringing about a reduction in the total ton-mile movement of commodities.

The last named causes of diminution of railroad traffic probably represent national and international economic developments. Presumably they are in the public interest. They suggest this question: If the railroads are successful in their campaign for legislation to restrict the motor vehicle, will they then turn to attempts to impede other forms of economic progress and seek legislative interference with all manner of creative effort discordant with their interests?

Acknowledgment.—From the 1932 Annual Report of the Atlantic Refining Company.

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RUBBER PAVEMENT IN PRAGUE.—D. C. Bliss, U. S. Consular Agent at Prague, Czechoslovakia, reports in Foreign Highway News, that a Czechoslovakian rubber goods factory has offered to pave, gratuitously, a sidewalk in the city of Prague with rubber blocks. The pavement will be laid for experimental purposes and will consist of solid rubber blocks vulcanized cold, a secret process of the company.

The Interest of the Railroads in Highway Construction

ONE should not question the right of any man openly to plead his cause as he sees it, nor should anyone object if those who are interested in the railroads give every possible attention to the protection of railroad business. Interest in the business handled by the railroads is by no means limited to those who own them and to those who are employed by them. A much larger number have a personal interest in railroad affairs on account of the insurance and the savings accounts they maintain. But even among those who have none of these incentives for interest in this matter, there is still a very real cause for concern over the present position of the carriers for the cost of pretty much everything men use is affected by the carrying charges that are generated by moving it from the original producer to the ultimate consumer. In all fairness it may, therefore, be said that everyone has a real interest in the railroads and that everyone who has given serious thought to this matter must realize the desirability of maintaining the financial stability of these carriers.

But even after admitting the importance of maintaining the financial stability of our railroad systems does it follow that stopping highway construction will strengthen their position? The work which has been done on the highways during the past 15 years has produced a well integrated system of state highways of which over 250,000 miles have been improved. In this system the principal trunk lines have been built to high standards. The main laterals have not been as highly improved but are reasonably adequate for present day traffic. As a result, the highway system as it stands today provides about all the facilities for direct competition with the railroads that a highway system can provide. It is quite essential that those who are considering the position of the highways as the basis of competition with the railroads bear this in mind. It is a vital consideration. The highways that can be used in direct competition with the railroads are in existence today as highly improved facilities. Stopping highway improvement will in no wise lessen their availability to those who wish to use them for this purpose.

On this account the traffic that has been lost by the railroads is of no importance in any consideration of future highway construction policies. It cannot be recovered by stopping highway construction, for the highways on which it moves have been constructed and without further construction activity will remain public facilities for years to come. Nor can this loss of traffic be greatly increased by further highway construction, for the great bulk of the highway construction of the future lies on secondary and tertiary feeder lines which are expected to serve the comfort and the convenience of the public rather than to carry commercial traffic in competition with other transportation facilities.

This statement is not intended to imply that there will be no further diversion of the traffic now handled by the railroads. On the contrary it is generally admitted that such diversions have increased rather steadily during the past few years and that, at least as long as present economic conditions prevail, they are likely to continue to increase. But these diversions are quite unrelated to the fact that the highway system is being expanded. Indeed, they probably have no relation at all to this expansion or at least none of consequence. They are related to the fact that the speed at which motor vehicles can be safely operated has been greatly increased, to the fact that the cost of operating motor vehicles, both passenger and freight, has fallen steadily and rather rapidly, and finally to the fact that, in the commercial field, the general reliability of the service offered has improved a great deal. In short, the increasing volume of business that truck and bus companies are handling is due to improvements in the equipment at their disposal and to improvements in management. As long as these improvements continue, the volume of traffic diverted to the highways will continue to increase unless railroad management so far alters its attack on this problem as to confront the better and more economically operated equipment constantly being offered for use in the highway field and the constantly improving management applied in this field with at least equal advancements in equipment and in management. This will remain true whether more highways are built or not. Future construction offers no real threat. From the standpoint of traffic diversion, future programs are not, then, the legitimate cause of any alarm to those interested in the prosperity of the railroads.

On the other hand, highway construction does provide the railroads with a large volume of business. It is to the maintenance of this business rather than to complaint over such business as has been lost to them that the railroads should address their attention. The interests of their employes as well as the interests of the owners of railroad securities will be best served if railroad managers adopt the usual rule of encouraging their valuable customers. Certainly they can gain nothing by destroying their customers.

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6600 Miles Additional Secondary Roads Recommended in California

The California Highway Commission and the Department of Public Works on March 15 submitted a report to the state legislature recommending approximately 6,600 miles of county roads for addition to the state's secondary highway system, including connections in and through cities. A similar alternative report of a lesser mileage also was submitted.

The resolution specifies that the additions shall be made in such a manner as to bring about an equality of secondary mileage between the northern and southern counties.

The 6,600-mile report adds approximately 2,743 miles of county roads and 159 miles of city street connections for the north and 3,435 miles of county roads with 262 miles of city street connections for the south, providing an equalized secondary mileage of 4,844 miles for each section.

The lesser mileage report totals 2,539 miles. It provides the same mileage of city street connections as the larger list and gives approximately 713 miles of county roads to the north and 1,404 miles to the south, bringing the equalized mileage for both sections to 2,813.7.

EDITORIALS

Half a Billion Dollar Federal Appropriation for Roads

As we go to press it is announced that the president favors a federal budget of $500,000,000 for highway construction during the coming 12 months. This is about equal to the combined state and federal expenditures for construction during a normal year. Hence there is assurance that roadwork will be conducted this year upon an unprecedented scale, if congress acts favorably upon the president's program.

We trust that no attempt will be made to "make work" by any restrictions as to the use of machinery. Men using machines are vastly more efficient than men using hand-tools, and the $500,000,000 will get into circulation just as quickly when road machinery is used as when it is not used. It is no exaggeration to say that the public will have five times as many miles of improved roads to show for its $500,000,000 if all the work is done by American methods than if it is done by Chinese methods.

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For What Kind of Public Works Is the Latent Demand Greatest?

PRESIDENT ROOSEVELT has always favored extensive public works construction as a means of reducing unemployment. He has recently repeated his advocacy of such a program. The success of the program will depend mainly upon two factors: first, its magnitude; and, second, the kinds of public works that are to be undertaken.

As to the magnitude of the program, it is clear that the severity of the depression calls for construction on a very large scale. No ordinary expenditures will suffice. A federal bond issue of three billion dollars would be none too great for public works to be completed within 18 months.

As to kinds of public works, the program should be one that will insure a speedy beginning of construction in all parts of America. It should result in works for which there is great latent demand. It should involve works that do not require approval by local balloting. There is no type of construction that meets all of these requirements so well as that of highway construction.

One of the president's advisers has been quoted as saying that improvement of highways that parallel railway lines should not be undertaken now, because the resulting competition will serve only to increase the financial difficulties of the railways. But that adviser has evidently failed to realize that America has long been engaged in building a system of highways that knits together the towns and cities, irrespective of railway lines. It would be foolish to build roads only where railways do not exist. Centers of population should be connected by improved roads as well as by railways, and this has always been the primary policy of highway engineers and the desire of highway users. The railway is one kind of transportation plant. The road and its motor-vehicles are another kind. Some competition between them is inevitable, and, indeed, desirable. The 25,000,000 owners of motor-vehicles would be seriously injured were highway improvement restricted to roads that do not parallel railways.

Judging by the number of owners of motor-vehicles, and by their continued use of them during the depression, the latent demand for improved highways is greater than for any other type of public works. Vast sums might be spent for postoffices, but how many motorists would vote for such expenditures in preference to road improvement? The present postoffice buildings serve the purpose well enough, whereas 80 per cent of our road mileage is very muddy in wet weather, very dusty in dry weather, and dangerous to drive over in any weather at the high speed that is prevalent.

The building of waterpower plants might consume millions of public dollars, but there is probably not a large hydroelectric project in America that would attract private capital in normal times. Steam power has been so greatly reduced in cost that new hydroelectric projects are rarely given a second thought by the owners of privately owned power plants. If this objection is not sufficient as an argument against such projects, there is the very weighty objection that no part of America is without adequate development of power. On the other hand scarcely any part of America has an adequate system of improved roads.

Reforestation may well be undertaken in certain limited areas, but here again we find neither public demand nor a strong likelihood that such projects will be profitable. It has been argued that river floods are mainly due to rapid runoff where trees do not exist. One of the greatest floods of the Mississippi River was witnessed by De Soto in March 1543, when the river overflowed to a width of 20 leagues. The Indians told De Soto that such floods occurred every 14 years. As a matter of fact tree-rings disclose a 14-year rainfall cycle, one of whose peaks was 1543. Meteorologists are agreed that river floods are not appreciably affected by changes in tree acreage in the drainage basin.

In weighing public demand for improved highways too little consideration is usually given to the fact that nearly every family in America owns an automobile. The most expensive single investment of the typical family is its "car." Dealers in "automobile paper" state that a family will lose its furniture rather than its motor-car if a foreclosure is threatened. Now, is it reasonable to suppose that such tenacity of ownership of highway vehicles is not accompanied by the desire to be able to drive over dustless, mudless roads? By the very act of buying an automobile the typical purchaser has voted in favor of improved highways. Since 80 per cent of our road mileage is unimproved, the greatest field for desirable public works projects is certainly the highway field.

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How to Restore "Velocity of Money Circulation"

IT has been argued that because there is more money "in circulation" now than in 1929, it will be futile to increase the currency if the object is to restore prices and wages to the level of 1929. But those who support this argument fail to consider the effect upon velocity of circulation of money. During the World War a 60 per cent inflation of our per capita currency led to a 30 per cent increase in its annual rate of turnover, or velocity of circulation. Hence there resulted a rise of prices of about 108 per cent; for 1.30 (velocity) $\times$ 1.60 (money) = 2.08, or a 108 per cent price level above the prewar level.

In 1920 the price boom ended, and in a few months the velocity of circulation returned to the prewar level, leaving prices about 60 per cent above that level.

We now have a velocity of circulation that is far below normal, and the great problem is how to restore it to normal as quickly as possible. The recent change in the law that controls banking has restored confidence in banks, but has failed to increase velocity of money circulation appreciably. Hence many business men and farmers are advocating some form of currency inflation. One group favors decreasing the number of grains of gold in the dollar. Another group favors printing fiat paper money. There is danger in either of these plans. Yet there may be greater danger in waiting for unassisted "nature" to "take its course." Perhaps it would be wise to inflate the currency by issuance of sufficient fiat money to cause a moderate rise in prices. Then the expectancy of a continued rise would bring about an increase in the velocity of money circulation. Let merchants witness rising prices, and they will cease their hand to mouth buying, and stock up. The very act of a general stocking up will cause an increase in velocity of circulation. It will put men back to work in the factories. Their purchases as individuals will increase the velocity of money circulation, and so on.

The danger from a currency inflation by the printing of fiat money is that the inflation will not be halted prior to the return of velocity of circulation to normal. In that event prices will rise far above the level of 1929, just as they did in 1920, which would be bad. But have we not reached a stage that justifies taking such risks as this, in order to restore the 1929 level quickly?

Since commodity prices respond more rapidly than wages to currency inflation, those who have jobs will be temporarily unfortunate. On the other hand more men will be put to work, and eventually competition among employers will cause wages to rise.

There is no record of any previous attempt to revive business by inflating the currency. Hitherto all great inflations of currency have occurred during wars, if we except the times when monarchs have arbitrarily ordered reductions in the weight of the silver or gold units of value. Should the proposed inflation of currency have the desired effect, it will mark a great step toward the ironing out of the business cycle curve, and will lead to a controlled currency. This alone will not eliminate the business cycle, for controlled credit will be necessary to prevent wide fluctuations in the velocity of circulation.

In 1929 the combined mortgages and bank loans in America exceeded $200,000,000,000. Other debts were about $100,000,000,000. Since the total American wealth was about $400,000,000,000, the total debt was 75 per cent of the total wealth. This represented such an excessive use of credit that it spelled disaster. The storm broke in the fall of 1929, and now, 3.5 years later, we see a lifting of the clouds. To dispel them rapidly a great experiment is about to be tried. We believe that it will succeed.

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Some Hints for Inventors

IN the shop of an old inventor with whom the writer worked for a time there hung this motto: "What the hand does, a machine can do." Perhaps the motto expresses undue faith in machinery, but it is the sort of faith that inventors should have.

This old inventor, Ross by name, was wont to add: "But don't let your machine imitate the hand." He went on to explain that the fingers and the arms are levers that move back and forth. Their motion is a reciprocating motion, whereas rotary motion is the most effective in machinery. For example, he said, a carpet sweeper has a rotary broom, whereas a broom wielded by the arms moves back and forth. He had invented many successful machines to take the place of hand-work, notably a harvester and a label-paster that pastes labels on tin cans, etc. In each case he was successful when he ceased trying to imitate human operations too closely.

Several other inventors have had similar experiences. One of them undertook to invent a machine that would make bluing balls. When he found that several previous efforts to imitate the work of the human hand had failed, he resolved to abandon that line of attack. In making bluing balls by hand, the bluing powder is first moistened and rolled into a dough, out of which little "biscuits" are stamped. These are rolled between the palms of the hand until they become spherical. This man got the clue to his invention when he chanced to see some pellets of bluing powder upon which rain had just fallen. He inferred that as each raindrop rolled down the slope of the pile of powder, it had gathered up enough to make a spherical pellet. So he proceeded to do artificially on a large scale what nature had done on a small scale. He mounted a barrel on an axle, put some bluing powder into the barrel which was rotated while water was squirted into the barrel. This artificial rain made pellets which grew into balls (very much as snow balls grow) whose size was regulated by the length of time and rate of rotation of the barrel and the quantity of water sprinkled upon them. In a few hours he solved a problem that had baffled several other inventors for months.

At times there appears to be no substitute for the intelligence that guides the hand. Thus in separating diamonds from their "blue ground" matrix, only the hand guided by the eye was effective, until one day a man chanced to observe that a diamond that fell upon a thin layer of grease adhered strongly to it. Strangely enough neither quartz nor any other common mineral seemed to adhere so strongly to grease. Hence he found it possible to substitute grease for the human eye and the hand, for when the "blue ground" containing diamonds was washed down an inclined table coated with grease, only the diamonds were clutched by the grease. Here was no imitation of the human hand and eye but a brand new substitute for them.

Until men invented boats, the legs were their only means of land transportation—either their own legs or those of animals. Legs like arms operate back and forth. Had some early inventor attempted to produce a transport machine having legs, he would have failed. The first transport machine was probably either a floating log, or a rolling log; the former being the progenitor of the boat; the latter of the two-wheeled cart or the wheelbarrow. In the case of the wheelbarrow we have reciprocating legs replaced by a revolving wheel. This was mechanically efficient because the load was not lifted intermittently. A walking man lifts his weight every step. It became economically efficient not only for that reason but because men or animals could haul much greater loads than they could carry. The wheel and axle is man's first great mechanical invention, with the possible exception of the bow and arrow. In the wheel we see no imitation of the legs. In the bow we see no imitation of the arm, for the arm does not hurl a spear by virtue of energy stored up in a spring.

When man successfully rivaled the birds, it was not by imitating the up and down motion of their wings, but by using "planes" driven by a rotating propeller.

These examples serve to indicate the wisdom of avoiding a servile imitation of the operation of the arm or leg or wing. On the other hand, there have been many occasions when close imitation of nature has led to successful invention.

Should "Cut-Throat" Prices for Cement Be Demanded?

Cement prices in 1931 and 1932 were "cut throat" prices in many instances, as will be evident from the following tabulation of the bidding price per barrel for cement to be used on Illinois highways during the last 15 years:

1919.....$2.04	1920.....$2.03	1921.....$2.04
1922..... 1.86	1923..... 2.06	1924..... 2.15
1925..... 2.15	1926..... 2.15	1927..... 2.20
1928..... 2.00	1929..... 1.98	1930..... 1.78
1931..... 1.29	1932..... .94	1933..... 1.62

These prices include freight to county seat, after deducting allowance for bags and discount.

Because the recent bids of $1.62 were much higher than the "cut throat" bids of $0.94 a year ago, the governor of Illinois and other state officials have charged collusion among the cement companies. The same sort of a charge was recently made by Secretary Ickes when ten companies submitted identical bids of $1.29 per barrel for 400,000 barrels to be used in the Boulder Dam. Mr. Ickes points at a 20 ct. lower bidding price for cement at that dam a few months ago. Significantly enough the charge of collusion is never made when a record breaking low price is bid, but only when such a price is exceeded.

For reasons given in an editorial article in our April issue, cement companies quote identical prices for delivery at a given point, because their product is of standard quality. Gasoline at the different filling stations in a given city sells at the same price if it is the same quality, yet no one charges the gasoline dealers with collusion. They merely display common sense, except upon those brief occasions when a "gasoline war" is in progress.

President Roosevelt stated in his radio address the other night that he aimed to bring not merely farm prices but all commodity prices back to about the levels that prevailed in 1929. We suggest that he repeat that part of his address to Secretary Ickes.

Evidently Mr. Ickes has no such plan of reflation, but favors a continuation of "cut throat prices."

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Newton Plus, Not Versus, Einstein

SPEAKING of Newton's theory of gravitation, Waldemar Kaempffert recently said: "And yet the work of Einstein proves that Newton, like all his predecessors, had created a universe in his own mind. His 'forces' were only new names for Kepler's 'virtues' and 'animal faculties,' with the difference that the pushing and the pulling could now be accurately measured. * * * Newton by no means exorcised Kepler's 'animal faculties' because he called them 'forces' and showed how they could be measured."

The general drift of Kaempffert's argument is that each of 5 great Cosmologists has invented a universe that is as unreal as the one invented by Aristotle. Of Potolemy, Capernicus, Kepler, Newton and Einstein he says: "As we look back 2,265 years it is clear enough that Aristotle created this universe, and not God. He did exactly what every cosmologist has done since, including Einstein. He projected his mind into space and took its reasoning, its dream picture, for reality."

Kaempffert goes on to voice the metaphysical theory that physical reality is unknowable, if indeed it exists. He closes thus: "Everywhere we see mind at work. Our mind or some greater mind? No one can tell. And so the age-old question presents itself: Is the universe unknowable?"

The fact that no scientific theory is perfect is thought by some scientists, and by many metaphiscists, to be good evidence that man cannot penetrate the secrets of nature, and must remain ignorant of physical reality. But it is unsound reasoning to infer complete ignorance where only partial ignorance exists. From Aristotle to Einstein not one of the six great cosmologists was entirely in error. Hence to hold up their known errors as evidence of man's utter inability to understand nature is beside the point at issue.

In order to make the metaphysical argument more plausible, it is stated that Einstein has shown that no gravitative force exists, all motions being due to a "warping of space." But when we try to picture a space-warping that results in motion, we go right back where we started, namely, to a state of ignorance as to the ultimate cause of motion. On this score Einstein helps us as little as did Newton. Newton candidly admitted inability to explain gravitation. He intimated, in private letter, that an ether seemed essential to our explanation of gravitation, but Kaempffert errs when he says that Newton invoked ether to explain gravitation. Newton's gravitational theory, as published, assigned an unexplained ability in every particle of matter to cause every other particle to tend to move toward it. Einstein's "space warping" is equally devoid of an explanation of why space is "warped" by matter. He speaks of a "gravitative field," but comes no nearer an explanation of the cause of gravitation than did Newton. Einstein denies the existence of an ether, but Newton never included an ether theory as part of his system of cosmology. Newton even denied the truth of Huygen's theory of light as a wave in ether.

Newton's laws of gravitation are not declared to be untrue by Einstein. Einstein discovered that all energy gravitates, and he inferred, therefore, that when a planet's velocity increases, its gravitative effect increases. This does not mean subtracting from, but adding to the Newtonian theory of gravitation. It is Newton plus Einstein.

Einstein substitutes "space-warping" for "gravitative force," but he has been just as incapable of telling us by what mechanism space is warped as Newton was in telling us by what mechanism gravity acts. Einstein has not destroyed but has broadened the scope of the Newtonian theory of gravitation.

It is unfortunate that a scientist of Kaempffert's ability has apparently espoused the doctrine of the complete mutability of scientific theory, but it is perhaps more regrettable that in doing so he has said that Newton was in error on a subject upon which he never published an opinion, namely, the cause of gravitation.

W. P. Gillette

County and Township Roads

A Section Devoted to the Interests of Those Responsible for Secondary Road Improvement

A First Class County Road at Low Cost

By S. E. Fitch
County Superintendent of Highways, Chautauqua County, N. Y.

POSSIBLY all of the various operations outlined in this article have heretofore been described separately in various engineering magazines but the advantageous results, both in quality of pavement as well as in costs, of combining all these modern ideas in the construction of a single project can so well be brought out by a description of the Hanover Center Road No. 90 built by the Chautauqua County Highway Department in 1932, that perhaps some repetition may be justified.

The various features combined here were as follows:

1.—The control of capillarity in and under the pavement by oil treatments of the subgrade and of intermediate layers of pavement.

2.—The cheap removal of the coarse pebbles from a bank run foundation without elaborate plant but by a power pulled raking device.

3.—The crushing of these salvaged oversize pebbles for use in the top course by a traveling crusher.

4.—The use of a traveling bituminous mixer to give a thorough mix with precise control of the percentages of bitumen to the crushed aggregate which method also allows the use of a viscous heated bitumen.

5.—The use of a 10 wheel pneumatic power grader to spread the mixed materials in place for rolling.

The pavement is 17 ft. in width and 10 inches in depth, the road-bed 37 ft. between ditches. The drainage structures conform to New York State Highway Specifications for firstclass roads. The riding qualities are better than the average firstclass state highway and the pavement has gone through the winter with no indication of raveling and has every appearance of being as good and as durable as a road produced by a stationary plant mix of the Amiesite or similar types.

Subgrade Stabilization.—To better understand the reasons behind the design of this type of road and the operations involved, it may be well to recall that the intensity of pressure from a wheel load at the various depths of a pavement varies. It is greatest at the surface or point of wheel contact and decreases with the depth, the decrease being approximately as the square of the distance from the surface. The bearing power of the various parts of the pavement may for economy's sake vary in accordance with this intensity of pressure, so long as the pavement will resist the destructive effects of the wheel loads at the surface, will have bearing power slightly greater than the maximum intensity of pressure at any depth, and will have sufficient depth to distribute the load over a large enough area of subgrade so that the intensity of pressure on the subgrade will not exceed the bearing power of the soil, then the pavement will be stable.

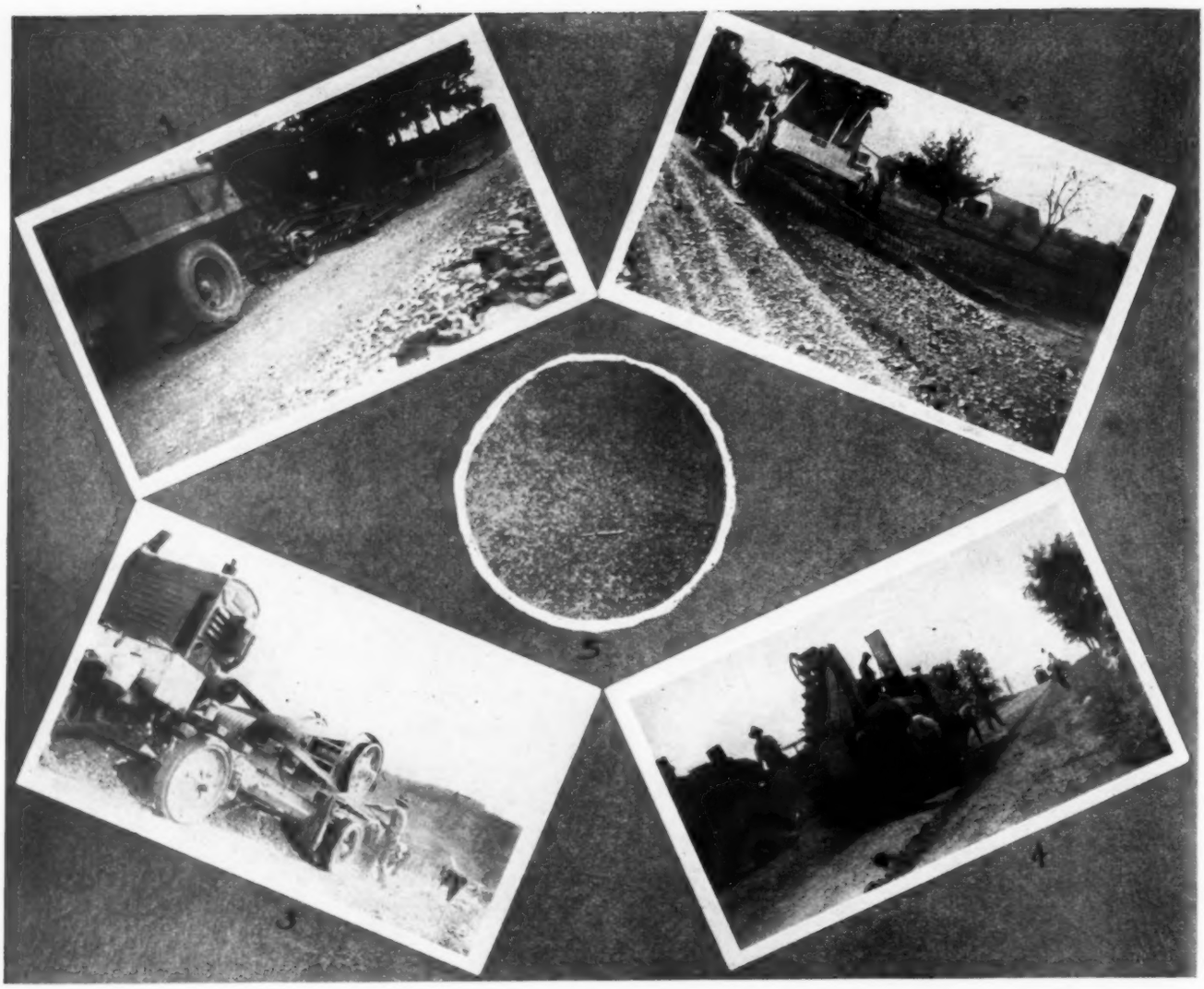
It has been customary for years to roll the subgrade of pavements to give it additional bearing power. In some climates such as ours where freezing and thawing is frequent and where soils frequently have high capillarity, the bearing power of the subgrade in the spring, by reason of capillarity and consequent frost boils, is greatly reduced. The subgrade may then in places become a thoroughly saturated soupy mass. When oils and tars are mixed with the soil they greatly reduce this soil capillarity and while we need much more information on what kind of bitumens are best for this purpose and how much should be used to stop capillarity, nevertheless economical results may be obtained by an intelligent guess, particularly when the bitumens are as cheap as they were in 1932.

From the above it is quite evident that in our climate a mixture of bitumen with the subgrade will greatly stabilize the subgrade and in a way the oil treated soil will then act as a part of the pavement and increase its effective depth, thereby permitting the use of a thinner foundation course to obtain the same strength. Indeed in some parts of the United States where the climate is not severe, oil treated soils are the only foundation necessary for pavements carrying light traffic. For these economical reasons Chautauqua County now oils the subgrade in all locations where capillarity is high or where the soil conditions are poor.

Construction Methods.—The method of constructing the Hanover Center Road, which was 4.11 miles long, was as follows:

The road was carefully graded, 37 ft. between ditches, and a trench for the foundation, 18 ft. wide, was thrown out by blade graders. The subgrade was then carefully trued up with a maintainer after which 0.4 gal. per sq. yd. of asphaltic material MC-3 (See Low Cost Roads and Bridges by Brown and Conner for new Asphalt Institute Specifications). Asphalt Institute Specification was applied and lightly covered with material from the shoulder to keep the oil from picking up by wheels.

After this oil had set up, run-of-bank gravel from a nearby pit was loaded on 5-ton, dual pneumatic tired trucks by power shovel and deposited in a 9-in. layer (loose) through ordinary spreader boxes. To further level this gravel and remove the coarse pebbles (over 2 in. diameter), a "York Rake" pulled by a 5-ton truck, was run several trips over this foundation course. The



1.—Smoothing the surface of the gravel. 2.—Raking the oversize stones out of the gravel into a windrow to the side of the roadway. 3.—Crushing the oversize gravel in a traveling homemade crusher. 4.—Mixing the surfacing material with bitumen in a traveling bituminous paver. 5.—Texture of the finished surface on Hanover Center road number 90.

diagonal rows of spring harrow teeth of this machine left the oversize pebbles in windrows at each edge of the foundation. The foundation course was then thoroughly rolled and allowed to stand as long as possible (where feasible it should stand over winter). When thoroughly consolidated, it was again smoothed up with a maintainer and given a treatment of 0.3 gal. per sq. yd. of tar of viscosity below 13 at 40° C. This was not covered.

After the tar had soaked in and set up, a traveling crusher was run over the road and the oversize pebbles previously raked out were tossed into the crusher by men with stone forks and crushed to a maximum size of 1¼ in. and this run-of-crusher material dropped in a windrow under the crusher in the center of the road. The windrow of crusher material was when necessary supplemented by enough additional material from the pit to give about 530 cu. yd. (loose) per mile. This additional material was selected from such parts of the pit as would give as good a gradation of sizes as was readily feasible without extra cost.

This windrow was then run through our traveling Cedar Rapids bituminous mixer and mixed with 4.3 per cent by weight of tar having a specific viscosity of 73 at 40° C. The mixer dropped the mixed material into a windrow at the rear of the machine where it was spread out by a power blade grader equipped with dual tandem pneumatic tires in the rear and single pneumatics in front. (This type of machine on trial proved to be superior to the same machine equipped with steel crawlers.) After this spreading, this course was rolled with an eight-ton tandem roller. Traffic was permitted over the road at all times. The percentage of tar used gave a rather lean mix with no tendency to shove or bunch but which later began to ravel a little under fast traffic. To stop this raveling a light treatment of about 0.15 gal. of tar per sq. yd. was applied without cover. This scheme gives better results than to increase the percentage of tar in the mix.

After this bottom course of mixed gravel had set up, a windrow of crushed slag from Buffalo was hauled by truck, furnished and delivered on the road, with a 35 mile haul, for $2.00 per ton. This crushed slag for top course all passed 1½ in. screen and had most of the dust screened out. For a pavement 17 ft. wide about 590 tons per mile were used. This was then run through the bituminous mixer, using 4.8 per cent by weight of tar with a viscosity of 73 at 40° C. The tar for both bottom and top course was heated in the tank cars to about 170° F. and mixed at 160° F. (*For an illustrated description of the use on other roads of the York Rake,*

the crushing outfit and the bituminous mixer see article by the author in ROADS AND STREETS *of January,* 1932.)

The material for the top course was spread and rolled in the same manner as the bottom course, described above. This lean mixture was allowed to cure several weeks and then given a surface treatment of ¼ gal. of tar per sq. yd. having a viscosity of 61 at 40° C. This was immediately covered with 20 to 25 lb. of pea size slag per sq. yd. and again very thoroughly rolled, additional slag cover being added by hand to any black spots as the roller brought the tar to the surface. The resulting pavement, shown in the accompanying illustration averages 2 in. in thickness.

After inspecting several recent road-mix jobs in nearby territory and comparing them with costs and results obtained with the traveling plant-mix, I am more than ever convinced that the traveling plant gives a considerably better job at little or no increase in cost where there is any considerable quantity of work to be done. I am also of the opinion that a fairly clean run-of-bank gravel course can ordinarily be substituted for the slag top course at a further saving of about $800 per mile. The traveling crusher with 10 men will crush an average of about 100 cu. yd. in 9 hours. The bituminous mixer worked 11 days on 4.11 miles of bottom course and 8 days on the top course. The average rate of progress for all days when it worked at all was 0.43 miles per day. The high run was 4,452 ft. in nine hours. The costs of the various operations are given in the accompanying table.

DETAILED COSTS—HANOVER CENTER ROAD NO. 90 AND 90-A—4.11 MILES

(Pavement 17 Ft. Wide. Roadway 37 Ft. Between Ditches)

Item	Cost	Per Unit	Per Mile	Per Mi. Incl. Mach'y and Overhead
Pipe culverts	$1,044			
Conc. culverts and bridges	2,053			
Total drainage structs.	3,097		$752	$880
Rough grade	1,330		$325	
Fine grade	217		53	
Roll and trim	545		132	
Oil treat subgrade (asph.)	964	4.68c gal.	233	
Total	$3,056		$743	$870
6″ Consol. R of B gravel Found. Course—				
Royalty 9,374 cu. yds. loose	$ 704	7.5 cu. yd.	$172	
Load, haul and spread	2,088		508	
Sort, manip. and roll	890		216	
Surf. treat found. crs. (tar)	945	8.48c gal.	230	
Approx. 7,230 cu.yds. consol.	$4,627	0.64 cu. yd.	$1,126 mi.	$1,317
2″ Consol. Mixed Grav. Bottom Course—				
3,125 cu. yds. loose meas.	$ 234		$ 57	
Load, haul and spread	696		170	
Crush oversize	183		44	
Mix and manipulate	3,672		893	
Roll and heat bitumen	306		75	
Tar and other materials	3,209	8.48 gal.	781	
Approx. 3,700 tons Total	$8,300	2.25 ton	$2,020	$2,363
2″ Slag Mixed Top Course—				
2,786 tons slag (incl. cover)	$5,675	$2 ton dlvd.	$1,381	
Mix and manipulate	2,331	0.79 ton	567	
Heat bitumen and roll	575	0.20 ton	140	
Tar (incl. seal coat)	2,853	8.48 gal.	694	
2,925 tons, incl. bitumen (in place)	$11,434	3.91 ton 27.8c sq yd.	$2,782	$3,255
Signs, guard rail, underdrain and misc.	$3,756		$911	$1,066
Total cost of road	$34,270		$8,334	$9,751

Road Up-Keep and Your Car-Mile Costs

By C. N. CONNER

Engineer-Executive, American Road Builders' Association, Washington, D. C.

SOME five years ago when the Nation was just scaling the peak of that prosperity which we now miss so acutely, this question was put to the president of a motor car corporation:

"Do you think the average motorist is especially conscious of motor vehicle operating costs?"

"No, I do not," replied the executive, adding, "and it probably is an excellent thing for the automotive industry."

That condition has changed radically today. All of us are conscious of nearly all the factors of cost that go into our individual standards of living. We are anxious to reduce each individual item, whatever it may be, to make it conform to sharply curtailed income. One item of cost which figures in the budgets of nearly 26,000,000 homes and business enterprises is the operation cost of motor vehicles, be they private passenger cars, trucks or buses.

The effect of various type of roads upon the amount it costs you, or any other motorist, to enjoy the undoubted advantages of highway transportation is variable and increases as the road surface increases tractive resistance.

Every progressive step in the improvement of any highway from the stage of a dirt road to a hard-surfaced artery pays excellent dividends on the amount that each individual has contributed to the cost of its development in the form of gasoline taxes, registration fees and the like. That is apparent in the fact that it costs from 26 to 34 per cent less to operate an automobile on a fully improved highway as compared with one that remains to be improved.

In the case of rural letter carriers their cost of delivering mail is closely related to the expense of their automobile operation. They are particularly concerned with costs these days because of reduced income in the form of lower salaries and motor vehicle maintenance allowance per mile.

Their position makes them the natural allies of those individuals and agencies who are united today in a campaign to forestall a further increase in motor vehicle operation costs as a result of inadequate highway maintenance. There is nothing nebulous nor imaginary in this prospect. The clamor for reduced taxes brings us face to face with the threat that, through a lack of maintenance, our county roads will be allowed to go to pieces. It is a tragic fact that to save the nominal sum it costs to keep these roads in a reasonable condition there exists a willingness to risk destruction of the huge investments we have made to bring them to their present stage of improvement.

Where is the logic of it? Where is its wisdom? It has neither logic nor wisdom to support it. These facts should be called to the attention of the general public.

What are these facts?

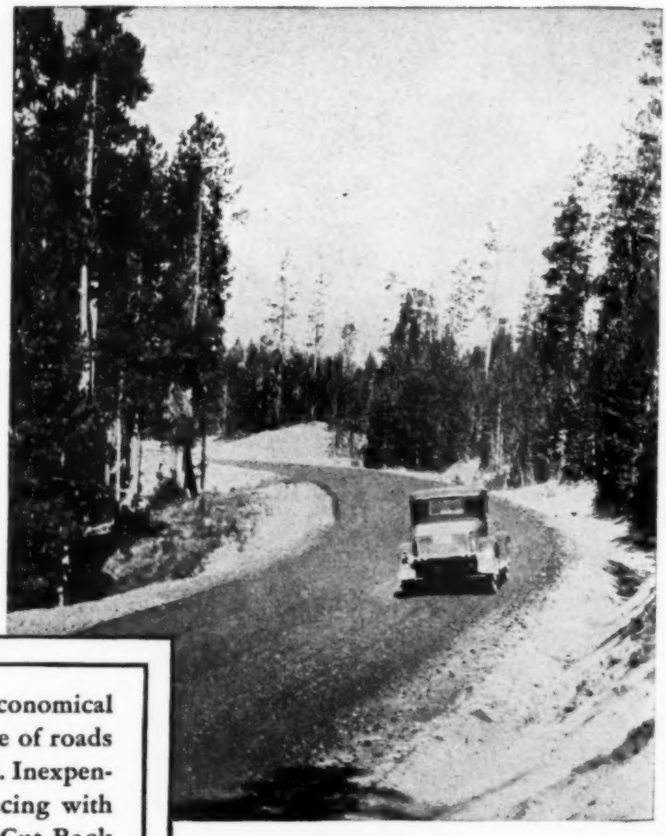
One of them is that it costs 6.43 cents per mile to operate the average, or composite, automobile, according to the best research data available. Nine items enter

THERE IS NO BETTER INVESTMENT FOR TAX FUNDS THAN BUILDING LOW COST ROADS

4 POINT ROAD PLAN PLEASES TAX PAYERS

● *Chicago, Illinois* — Smart highway officials through the Middle West agree that the Four Point Road Plan is the solution of this year's problem. Tax payers demand lower road costs, but will insist on adequate mileage as compared to previous years. The Four Point Plan is briefly:

1. Concentrate construction on local roads.
2. Use products of unquestioned quality.
3. Refuse all projects going beyond reduced budgets.
4. Keep mileage of roads up to previous years.



In the Middle West there are more miles of Stanolind Cut-Back Asphalt than any other kind. Low cost roads built with Stanolind Cut-Back Asphalt are both durable and economical.

● For economical maintenance of roads use Asphalt. Inexpensive resurfacing with Stanolind Cut-Back Asphalt provides fine riding surfaces on old road foundations without waste of previous investment or expensive new sub grade.

●

The logical local road material is Asphalt, and the logical Asphalts on the principle of buying only unquestioned quality are Standard Oil Company (Indiana) Asphalts.

May we ask one of our highway specialists to talk with you about how Standard Cut-Back Asphalt can help you to make a real record?

• • •

STANDARD OIL COMPANY
(Indiana) 104
910 South Michigan Avenue Chicago, Illinois

Please mention ROADS AND STREETS—it helps.

Applying Stanolind cut-back asphalt previous to mixing and surfacing, and in some cases rolling.

After application of Stanolind cut-back asphalt, it is thoroughly mixed with the mineral aggregate.

Close-up view of Stanolind asphalt and mineral aggregate after mixing and surfacing.

Completed roadway. As traffic runs over the road the surface becomes more compact and smooth.

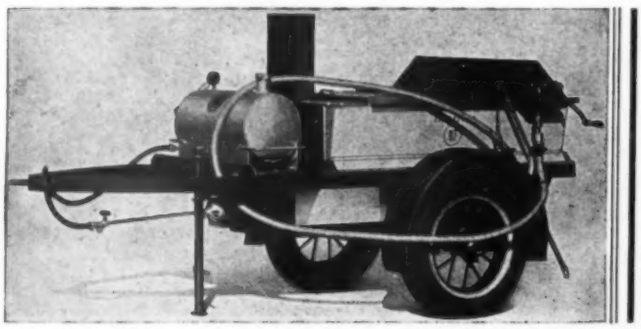
Don't

let worn-out Equipment cut into your HIGHWAY FUNDS

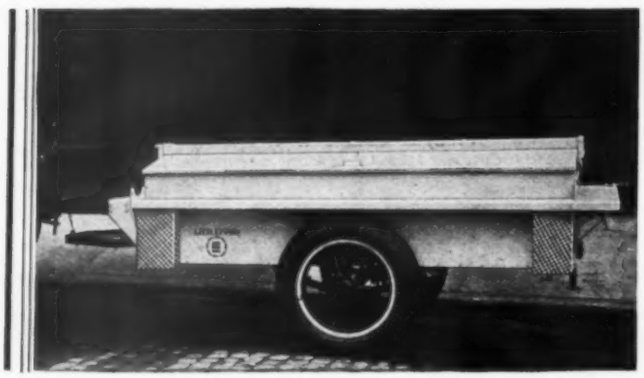
Worn-out equipment costs money. Every time there is a break-down, the result is delay —and delay means money. That's when new equipment helps you keep within your appropriation.

Tar Kettles don't last forever; neither do tool boxes, paving tools, or other maintenance outfits. Replacements must be made; but, there is no need to make a large outlay for new equipment. Take care of the good equipment you have and replace the worn-out pieces that cost you money to operate.

Keep your highway department operating on an efficient basis; re-equip with new Littleford outfits purchased at the lowest prices in the history of Littleford Bros. Write for a copy of our Road Equipment Catalog and select the outfits you need.



The Littleford No. 84-HD Tar and Asphalt Kettle, when equipped with our hand spray attachment, makes a complete low-priced maintenance unit ideal for penetration patch work.



Stop loss and theft of tools by keeping them in the Littleford HanDeeBox. It is made entirely of steel. One lock securely fastens both covers. There are no padlocks. The City of Cincinnati uses a fleet of twenty-two HanDeeBoxes.

LITTLEFORD

Road Maintenance Equipment

SINCE 1900

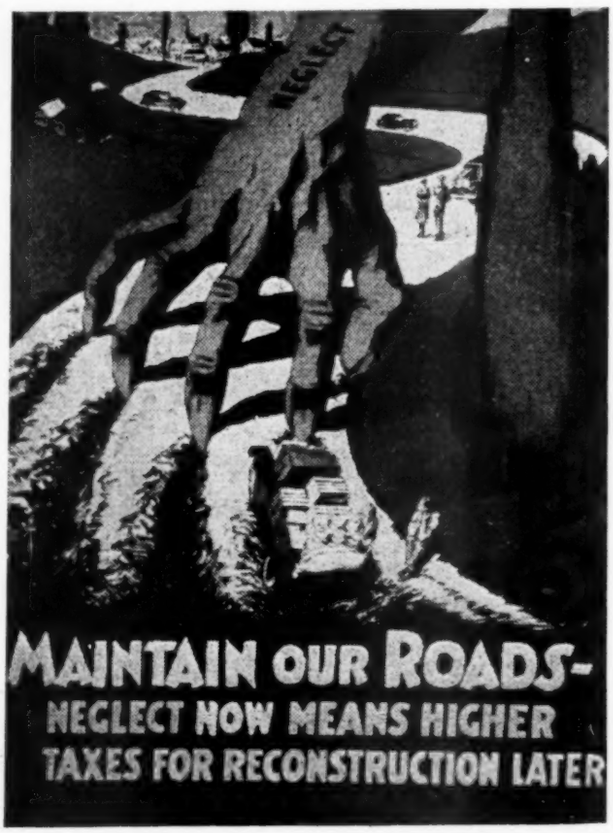
LITTLEFORD BROS. 454 E. PEARL ST. CINCINNATI, O.

into this cost per-mile calculation. Five of them, including the three most costly phases of car ownership, are directly susceptible to reduction or increase, depending upon the type of road over which the vehicle is operated. These five items are gasoline, oil, tires and tubes, maintenance and depreciation. The four fixed items, that is those which are not affected by highway conditions, are license, garage, interest and insurance.

Let us suppose that the road over which you are accustomed to operate your car every day is an intermediate type, such as a surface treated macadam. Through non-maintenance it reaches a condition that makes it no better than the typical unimproved road. In such a case it will cost you, or any other motor vehicle operator, an average increase of more than 1.07 cents per mile to run your automobile. Which would you prefer, to pay this higher operation cost or to contribute a small individual share to the sum that would maintain the road in an intermediate stage of development? There is no question but that you would choose the latter. You would prefer to donate toward and demand adequate maintenance, because it is less expensive. So, it is equally certain, will every other motorist when he realizes the truth of the matter.

Let us say, further, that your usual travels are over a high type road. Let it lapse into a state of disrepair that makes it the equivalent of an intermediate type, and the cost of operating the average car will increase .99 cent per mile. Or, should maintenance be ignored for a period long enough to put the road back to its original classification as an unimproved type, the difference in operating costs would be 2.09 cents per mile greater than if the road had been maintained.

These figures should be presented to friends and acquaintances who want all road work to stop in your community. When they realize their significance they will radically change their position on the matter. If they



Weather and Neglect Soon Tear Up a Road

do not, then one can add the indisputable fact that for every $1 paid for tires and tubes for cars driven on good roads, the outlay is $2.90 for vehicles operated on unimproved roads.

The point is that whatever the individual may save through a reduction in taxes which forces elimination of adequate highway maintenance from county, township, city or state programs, the amount is negligible as compared with the additional outlay required for his car's operation.

Let us look at the item of gasoline consumption in motor vehicles for a moment. The average car owner does not do it under ordinary circumstances.

All of us, for instance, are accustomed to thinking of our automobile engines as having this or that amount of horsepower. As a matter of fact, the power inheres in the gasoline. The engine merely is an instrument for converting it into useful work, or what we call performance. The engine has no power in itself but is designed to convert gasoline into power up to a certain point, dependent upon its design.

The type of road makes the engine's job amazingly easier in that it takes a much smaller amount of gasoline, or power, to perform a given job on a high-type road than on an unimproved one. Listen to these figures on a loaded two-ton truck on various types of highways:

On an earth road, the vehicle gave 5.78 miles to the gallon. A fair gravel road brought the average to 7.19 miles per gallon, while a well maintained gravel surface increased the miles per gallon to 9.39; and a paved highway gave 11.78 miles per gallon.

The best road, plainly, cut the engine's job in more than half and more than doubled the mileage yield per gallon of gasoline consumed.

Opponents of highway maintenance appropriations think they are looking at the whole matter from the essentially practical basis of dollars and cents involved. However, they merely think so. The fact is that on this basis their argument completely collapses. Highways have saved billions of dollars in transportation costs and we have spent too much money on them to see our investment jeopardized now; nor can we justify any such paltry saving as that involved in reducing maintenance appropriations.

Individually and collectively we have too much at stake to remain inactive in the campaign now being made to save our roads.

Acknowledgment.—Revised from a paper presented before the National Rural Letter Carriers' Association.

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Sevison to Retire as Head of Wyoming State Highway Department

At first meeting of the newly appointed majority (democratic) of the Wyoming Highway Commission, it was decided to replace Z. E. Sevison as the head of the department, when his term expires in June. Mr. Sevison has been State Highway Engineer of Wyoming for 16 years, or since the organization of the Department in 1917, and for the major part of that time he has been the executive head of the Department.

Mr. Sevison is president of the Western Association of State Highway Officials and for many years has been a member of the executive committee of the American Association of State Highway Officials.

He pioneered the bituminous treatment of gravel and crushed stone roads in the intermountain states and as a result this low-cost type has proven successful for a large territory.

PERFECT CONTROL *with the* LITTLEFORD SINGLE VALVE

Every operation of the Littleford Pressure Distributor—whether fill, spray, circulate or drain—is regulated by one control valve.

When the operating wheel is turned to "Spray", you get immediate positive pressure full length of the spray bar.

And then, when you're ready to cut off, a turn of the operating wheel to "Fill" stops the spray and draws material in the lines back to the tank—there is no stringing out or dripping.

Let us tell you all about the Littleford Pressure Distributor—you'll be interested in its easy operation and the way it heats material. Ask for our Pressure Distributor Catalog.

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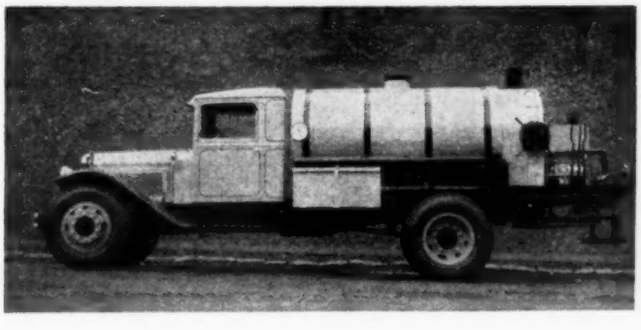

Township Builds Low Cost Road With Emulsified Asphalt

By E. L. BRACKEN
Vice President, Pennsylvania Association of Supervisors of Second-Class Townships

HIGHWAY problems of Tredyffrin Township, Chester County, Pennsylvania, are affected by factors both suburban and rural. Tredyffrin Township is located some twenty miles west of Philadelphia. It is crossed by U. S. Route 30, a few miles from Valley Forge Park, and is on the main line of the Pennsylvania Railroad. It has densely populated villages such as Paoli, made up largely of commuters, and

Biddle Road, Paoli, Penna., Asphalt Penetration Macadam Constructed on Six Per Cent Grade

rather sparsely settled farm areas. Even in the latter districts, however, the highway system must be built for fairly heavy traffic because of the proximity of Valley Forge, which draws considerable tourist traffic; because of the closeness of Philadelphia and its densely populated suburbs; and because of the location of several limestone quarries with their heavy traffic in the township in addition to farm traffic.

As the costs of both construction and maintenance of the township's system of roads must be borne largely by rural taxes, it has been necessary to find a type of road having both a low original cost and a low cost of upkeep, which would be suitable for all kinds of traffic the year round.

It eventually was decided that asphalt penetration macadam construction was best suited to our requirements. This type has a low initial cost. It can be constructed to meet the requirements of each individual road; it is sufficiently durable for roads carrying heavy trucks from the quarries and farms, and it makes an attractive road to serve the residential district and large estates. The maintenance of cost of asphalt penetration macadam is low, particularly as a result of the low interest charges on the initial outlay.

For several years Tredyffrin Township has used hot asphalt having a penetration range of 85 to 100 in the construction of its highways, and to a large extent for surface treatment. However, on two recent road projects emulsified asphalt has been used and the results obtained apparently have justified its use. At Paoli in July, 1932 a penetration surface using it was constructed on a residential street.

Part Surface Treatment and Part Penetration Macadam.—This road had been neglected for several years and was badly in need of repair, in addition to being quite narrow. It was decided that part of the road could be improved by widening it with penetration macadam shoulders, followed by the application of a double surface treatment over the entire area, while the remainder could be widened and then covered for the entire width with a penetration macadam wearing course, in both cases utilizing the existing road without scarifying or otherwise disturbing it.

Surface Treated Section.—After widening operation, pot holes and bad depressions on the section to be surface treated were filled with stone, the binder applied, and rolled. Then 4/10 gallon per square yard of Texaco emulsified asphalt No. 30, a "quick-breaking" type of emulsion, was applied to the surface by means of a pressure distributor. The treated surface was immediately covered with approximately 20 pounds of limestone chips, ranging in size from ⅝ in. down to ¼ in., and rolled. In about two hours the second application of 4/10 gallons was applied, covered with 15 pounds of chips ranging in size from ⅜ in. to 10-mesh, and rolled. It was intended to broom-drag the surface, but this could not be done, as the drag was not available.

Asphalt Penetration Macadam Section.—On the section of road covered with the penetration macadam, the procedure was as follows:

After widening, we spread a course of 1½ in. to ½ in. limestone, compacted to 2 in., and applied 9/10 gal. per sq. yd. of the same grade of emulsified asphalt as above. This was covered with 35 pounds of ⅝ in. to ¼ in. stone and rolled, brush-dragged and rolled again. The following day 6/10 gal. of the emulsion was applied and covered with 18 pounds of ⅜ in. to 10-mesh stone and rolled for a period of several hours. It was opened to traffic immediately but rolled again the next day.

Although part of this work was done on a grade between 5 and 6 per cent the emulsion did not run away. This was proven by the fact that there was no berm on one side of the road at this point, the low side, and any excess material would have appeared. It was noticed that the emulsion spread out from places where the distributor had made puddles, thus automatically preventing the formation of fat spots. This tendency of the material to spread and to be taken up by the voids in the surrounding area can probably be explained by the fact that the large voids have been filled with the smaller sizes of stone, making a very dense mass with small voids and additional surfaces to be coated. This density is further shown by the action of the roller, little movement occurring under the wheels from the very start of the rolling operation. Another indication of the thorough absorption of the emulsified asphalt is that after six months of traffic on this road, there has been very little discoloration of the surface, the original color of the limestone predominating. The slight discoloration present apparently is due to oil drippings from automobiles and dirt carried on to the surface, rather than to any bleeding or sweating of the asphalt. This absence of bleeding and sweating assured a non-skid pavement over a period of time limited only by the actual wear of the stone.

Practically all of the cover was held except in areas where the excess of stone was so great that some of it did not come in contact with the emulsified asphalt. Where the proper quantity of stone was applied it was held. By the time the emulsion reaches the tacky stage, the stone has become sufficiently imbedded to stay in place. This holding of all of the cover is another assur-

QUESTIONS *and* ANSWERS *Regarding* ACE JOINTS

By J. H. JACOBSON

So much comment has been caused—and so many questions asked—regarding the application of Ace Joints to concrete road construction, that a detailed explanation seems to be in order. I believe the following facts will prove of much interest to engineers and highway officials.

1. WHAT specific advantages are to be derived from the use of Ace Joints in highway construction?

Answer:

Joint No. 1:

This is an expansion and contraction joint scientifically designed to provide adequate expansion and contraction in concrete pavements and at the same time provide adequate facilities for load transmission from adjacent slabs in a manner which will avoid structural weakness at the joint.

These joints are to be installed at proper intervals as determined by the highway designer. When used primarily to provide for expansion, the spacing of the joints is determined by the size of the expansion space and the anticipated temperature range. The recommended practice is to use the size affording three-quarters of an inch of expansion spaced approximately one hundred feet apart, with joint number 3, hereinafter described, spaced at twenty-five foot intervals for the controlling of intermediate transverse contraction cracking.

This joint provides a clear air space which is sealed against foreign matter by a permanent copper top seal and by copper end-plates which are removable for inspection of the joint. The joint is designed in such a manner that, once installed, it will last indefinitely. Even though the steel which forms the joint at the time of construction should completely rust away, after a period of years, the air space will still remain, properly protected by the top copper sealer strip and the copper end-plates.

The joint is provided with slip dowel bar sockets which are easily screwed onto the joint alternately on its two sides. These sockets are provided with a stop which marks the correct length of the bar insertion and the ends of the sockets can be bent down so as to rest against the subgrade and thus provide proper support during the pouring of the concrete. One end of the dowel bar is imbedded in one concrete slab and the other end is greased and inserted in the close-fitting dowel bar sockets which are likewise imbedded in the concrete. Three-quarter-inch smooth dowel bars spaced six inches from the edges or center joint and twenty-four inches center to center across the slab are recommended.

Thickened edges are obtained by means of triangular-shaped shoes which slip onto the outer ends of the joint so as to provide whatever edge thickening is specified by the highway designer. Removable copper end-plates are provided which close the ends of the joint and prevent the entrance of foreign materials. However, these end-plates may be readily removed whenever it is desired to make an inspection of the joint.

The ends of the joints are equipped with sliding anchor clips which go under the side forms and hold the joint in place during construction, and the joint can be thus sprung down to provide any crown up to two inches without lateral distortion. A wooden cap strip is provided to protect the copper sealer strip during construction. This wood strip is placed flush with the finished road and serves as a guide in screeding and finishing the slab. When the concrete has been placed, this wooden strip is removed and the small space above the copper sealer plate is filled with bituminous material.

Joint No. 2:

This is a longitudinal construction joint especially designed for the formation of the longitudinal joint which is commonly used in highway design. On account of its shape and design, it is possible to manufacture this joint with lightweight material and yet have sufficient lateral stiffness. The wing caps on

Advertisement

this joint are staggered at the ends in such a manner as to provide adequate end joining of the joint sections.

Slots are provided for driving pins into the subgrade to hold the joint in place during construction, and these pins have three contact points with the joint, one on one side and two on the other. The method of joining the sections heretofore referred to enables the longitudinal joint to conform to any degree of vertical curvature.

26-Gauge sheet steel is used throughout for the construction of the standard joint, but when specified, the wing top sections of the joint will be furnished in 12-ounce copper at an extra charge.

The longitudinal joint is punched at proper intervals for the insertion of one-half-inch deformed dowels across the joint. These dowels are imbedded in the concrete of adjacent sections so as to hold the sections together, thus taking advantage of the interlocking or load transmitting characteristic of this joint.

Joint No. 3:

This is a transverse contraction joint of a design similar to that of Joint No. 2, except that this joint is equipped with slip dowels, triangular shoes for obtaining thickened edges and sliding end-clips for anchoring the joint into place during construction by sliding the clips under the side forms.

The standard joint is made of sheet steel, but when specified, a copper wing top may also be furnished at an extra charge.

This joint provides a means of controlling transverse cracking by dividing the slab into sections of suitable length. Since these joints are equipped with dowel bars and sockets for load transmission, no weakness results from their introduction into the pavement slab. It is recommended that these joints be used at approximately twenty-five foot intervals between the expansion joints. At this spacing there is no danger of transverse cracks forming between the contraction joints.

2. HOW does the cost of using Ace Joints compare with the costs of other methods of taking care of expansion and contraction in concrete pavement slabs?

Answer:

It is generally acknowledged that there has not been a successful method of taking care of expansion and contraction of highway slabs until the American Concrete Expansion Joint Company developed Ace Joints designed so as to afford proper load transmitting features and adequate provision for the contraction and expansion of the concrete slabs.

Contractors have informed us that Ace Joints cost less than any other joint to install and after a survey of the prices of other joints, we are convinced that our price is considerably less per foot.

The benefits of using these joints greatly offset the initial first cost. In fact, these joints permit economies in other features of design which practically offset their cost.

3. WHAT proof is available to show that these joints will do what is claimed?

Answer:

An examination of these joints themselves is convincing; also, extensive tests of the joints have been made by the Illinois Division of Highways and the Pittsburgh Test Laboratory. Reports of their findings are available for your inspection. The Joint has been approved by the State Highway Department of Illinois for use on State and County highway construction by Ernst Lieberman, Chief Highway Engineer.

4. WHAT is the selling price of the Joint?

Answer:

The selling price is governed by the price of raw materials and labor at the point of production. At the present time, the No. 1 Joint sells for fifty cents per foot, the No. 2 Joint sells for five cents per foot, and the No. 3 Joint sells for five and one-half cents per foot, f.o.b. ....., all subject to proper discounts on quantity orders and in accordance with general trade practice.

◆ ◆

ACE JOINTS

"The Heart of the Highway"

THE AMERICAN CONCRETE EXPANSION JOINT COMPANY
123 West Madison Street
Chicago, Illinois

Advertisement

ance of a non-skid surface over a long period of time. Limestone was used entirely for large stone and fine cover. Although there was some dust in the aggregate, we experienced no difficulty in securing a good bond.

Our conclusions regarding this job are that low cost rural roads and residential streets can be built, suitable for heavy traffic to a thickness and using an aggregate and binder best suited to the conditions to be met. Such roads, because of a proper selection of aggregate, are denser and consequently more resistant to impact, wear and frost than uniform sized aggregates.

The type of binder employed because of its use as a cold application and its affinity for damp stone increased the number of working days thus reducing the fixed charges per day. Only one grade of emulsion was used for patching, penetration and surface treatment. It expedited the progress and reduced the equipment necessary for the job. Its non-tacky nature when first applied, permitted a further truing of the surface, thus allowing the use of broom-drags and straight edges.

The emulsion adhered to the aggregate in a thin film. The road was constructed of a graded aggregate that is inherently stable. The surface is skid-proof and will remain so over a relatively long period of time because the perfectly keyed aggregate presents a mosaic surface unaffected by temperature. There has been no evidence of bleeding.

▼

Would Merge Five Wisconsin Counties in One

A Taxpayers' organization which met at Three Lakes, Wis., recommended that Oneida, Forest, Florence, Vilas and Price counties be merged into one, that the county board of supervisors be abolished and that a new governing council, consisting of one man from each of the districts comprising the present counties be created to succeed the present county boards.

It was pointed out that the counties as originally organized were made of a size that any citizen would be able to drive in a day with his horse to the county seat. The use of the automobile makes this provision ineffective. While it is understood that private interests would fight against such a consolidation, yet if the rank and file of taxpayers could be shown what this top-heavy organization was costing them in taxes they might be willing to put behind them any idea of county patriotism or obligation to any county officers or county board member and vote to eliminate what was termed "a costly and useless organization."

It was stated at the meeting that the greatest drawback to the idea probably would be the influence exerted by county employes, numbering about 100, "most of whom would like to keep their jobs."—*The Improvement Bulletin.*

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A Correction

On page 119 of ROADS AND STREETS for March a statement is made that the electrical equipment for the Hudson River Bridge at Albany was designed and built by the General Electric Co.

The electrical equipment was designed by Waddell & Hardesty, Consulting Engineers to the New York Department of Public Works in connection with the steel superstructure of this bridge. The Zipp-Beckmeyer Construction Co. of Huntington, W. Va., as sub-contractors to McClintic-Marshall Corporation, worked out the field details and installed the electrical equipment, which was built by the General Electric Company.

Motor Vehicle Registration in 1932

Last year 24,136,879 motor vehicles were registered in the United States, state authorities have reported to the Bureau of Public Roads, U. S. Department of Agriculture. This represents a decline of 6.6 per cent from the preceding year. The automobiles, taxis and busses totaled 20,903,422, a decline of 6.5 per cent, and motor trucks and road tractors totaled 3,233,457, a decline of 6.7 per cent.

The gross receipts from registrations, permits, etc., amounted to $324,273,510. These funds were allocated as follows: State highways, $155,911,962; local roads, $75,964,336; payments on road bonds, $39,339,980; collection and administration costs, $17,550,422; and for miscellaneous other purposes, $35,506,810.

The total registrations and decline in registration from those of 1930 were as follows:

State	Total vehicles registered in 1932	Decline in registrations from 1930
Alabama	226,471	8.1
Arizona	94,947	10.1
Arkansas	136,503	24.5
California	1,971,616	3.5
Colorado	285,860	7.3
Connecticut	343,007	3.3
Delaware	52,851	4.3
Florida	286,091	11.5
Georgia	287,716	10.3
Idaho	95,325	14.6
Illinois	1,493,498	7.4
Indiana	796,815	7.6
Iowa	680,330	9.1
Kansas	504,367	9.8
Kentucky	293,265	10.1
Louisiana	242,748	7.7
Maine	171,757	8.8
Maryland	321,242	1.3
Massachusetts	801,909	4.6
Michigan	1,134,808	7.8
Minnesota	683,397	5.1
Mississippi	149,095	18.8
Missouri	717,460	4.7
Montana	109,129	14.2
Nebraska	375,716	9.7
Nevada	31,830	1.1
New Hampshire	106,431	4.6
New Jersey	857,850	1.4
New Mexico	76,767	5.6
New York	2,241,930	2.4
North Carolina	375,695	12.4
North Dakota	153,570	10.3
Ohio	1,589,524	7.1
Oklahoma	428,302	11.3
Oregon	259,271*	6.8
Pennsylvania	1,664,021	4.5
Rhode Island	133,408	3.2
South Carolina	177,020	13.1
South Dakota	161,933	16.1
Tennessee	298,713	14.8
Texas	1,191,324	8.2
Utah	99,851	8.3
Vermont	77,595	7.5
Virginia	370,587	2.3
Washington	446,001	6.0†
West Virginia	227,888	10.0
Wisconsin	694,652	7.9
Wyoming	56,226	9.5
Dist. of Col.	160,567	7.5
Total	24,136,879	6.6

*For registration year ending June 30, 1932.
†Registrations in Washington increased 6.0 per cent.

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MOTOR VEHICLES IN MEXICO.—On Jan. 1, 1932, the total motor vehicle registration in Mexico was 67,072 (a decline of 13,728 vehicles, as compared with Jan. 1, 1931) divided as follows: Passenger cars, 49,457; busses, 4,051; and trucks, 13,564. Preliminary reports for 1932 indicate a further decline.

A Review of the 1931 Connecticut Traffic Survey

By L. E. PEABODY

Senior Highway Economist, U. S. Bureau of Public Works

A REPORT of a survey of traffic in 1931 upon the highways of Connecticut was published by the Connecticut Motor Vehicle Department in June, 1932. The report is well arranged and supplies a volume of new and valuable traffic data. In the 1931 survey it was found that vehicles equipped with solid tires—the bête noir of the highway engineer—were but 0.38 per cent of all vehicles upon Connecticut highways. The recommendations of the report with respect to by-passes, the use of existing alternative routes and the proposal for the installation of one-way highways are particularly timely, and the report may be read with profit.

In the Foreword it is stated that "the survey will serve as a check on the estimate of traffic for 1930 made in 1926 by the Bureau of Public Roads of the United States Department of Agriculture in cooperation with the Connecticut State Highway Department."

This objective is but partially realized due to the fact that in the comparison of predicted and actual traffic (Table 6) the actual traffic was secured by the state for the period Aug. 1 to Oct. 15, 1931, while the predicted traffic was an average covering the whole 12 months of 1930. Thus the actual traffic used in the comparison, in the words of the survey report, is "for the period of the year when maximum traffic exists which, of course, is what the Department is primarily interested in, rather than in average yearly figures." Yet this actual traffic covers the peak traffic of 1931, while the predicted traffic with which the comparison is made, is a yearly average for the previous year, 1930.

Fig. 1.—Trends of Motor Vehicle Registration, Gasoline Consumption and Estimated Traffic in Connecticut

The differences between these two figures are further accentuated by the fact that foreign traffic in Connecticut, as in many other states, has increased as a proportion of total traffic during the years from 1923 to 1931. This factor, most difficult to predict, produces a peak traffic during August to October in 1931 which is relatively higher than traffic peak in the corresponding period of 1923, since foreign traffic flow is concentrated for the months in which the state of Connecticut secured the 1931 traffic data. Foreign traffic in Connecticut was 10 per cent of all traffic in 1923, and increased to 22 per cent in 1931 during the 2½ months of observation. This compares with similar increases in other states: Tennessee's foreign traffic increased from 2.2 per cent of the total in 1922 to 20.1 per cent in 1932; while Virginia's foreign traffic increased from 17 per cent of all traffic in 1926 to 22.8 per cent in 1931.

The Bureau's estimate of traffic in 1931 for the 19 stations of Table 6 total 90,357 vehicles per day, and if allowance is made for the fact that the actual traffic of 1931 in the Department's report is about 30 per cent higher than the average for the full year, the Connecticut figures for these 19 stations would total 89,923 per day.

The Department's survey confirms the use of gasoline consumption previously employed by the Bureau in similar surveys,* as the more accurate factor in traffic prediction. Gasoline consumption data was not available for use when the Bureau's forecast was made for Connecticut, since gasoline consumption records extend back only to 1922.

The traffic forecast made in 1924 by the Bureau is compared with gasoline consumption and motor vehicle registration in Figure 1. This was the first traffic forecast made by the Bureau and, so far as known, the first ever made for any state. The data available was limited,† and the methods in use have since been materially improved. Yet the data of Fig. 1 indicate that this somewhat primitive traffic forecast varies but slightly from the data on gasoline consumption, which is undoubtedly the most accurate reflection of traffic volume, and that the traffic forecast was far more accurate than that of motor vehicle registration, upon which it was based.

There are a few minor errors in the Department's report which will readily be picked up by the careful observer: thus in Figure 18 the 1923 motor vehicle registration is given as 141,019 cars although it is shown in Figure 16 at about 183,000 cars; again, in Figure 13 the percentages shown under "Classification of State Wide Traffic" are those listed under "Interior Stations" on the following page.

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WOOLLY ROADS.—A road pavement of chemically-treated wool which is said to set as hard as concrete is being tested in New South Wales. Wool of inferior market grade is used.—*Highway Magazine.*

*The Western States Traffic Survey, Public Roads, March, 1932.
†The New Hampshire Traffic Survey, Public Roads, October, 1932.

New Equipment and Materials

A New Drop-Forged Wagon Track

A 15-ton drop-forged steel wagon track, built and designed exactly like the track assembly of the Allis-Chalmers Model "L" tractor, has been brought out by the Allis-Chalmers Manufacturing Co., Milwaukee, Wis. The essential principles of this new long life wagon track are:

New Allis-Chalimers 15-Ton Drop Forged Wagon Track

1. Load carrying track wheels rolling on the rail of an endless track.

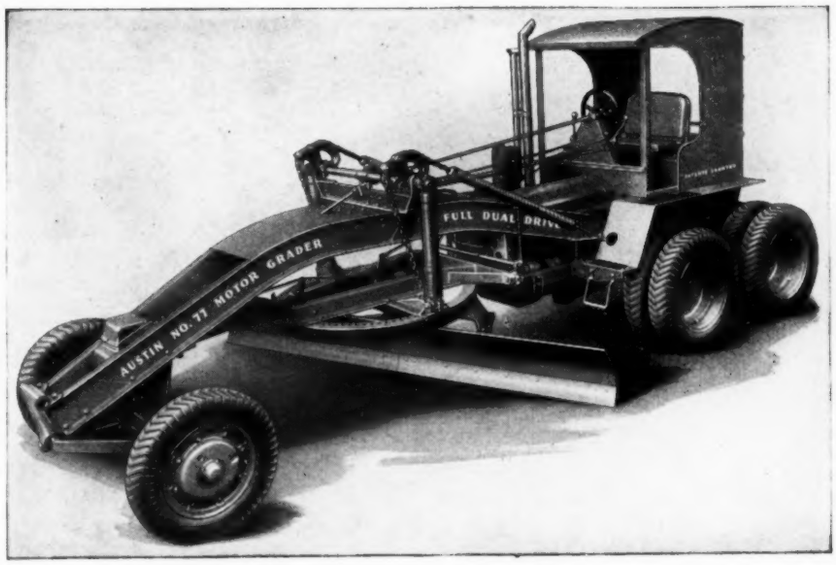
2. Idlers, or end wheels (non-weight carrying) for the purpose of picking up the track in the rear and depositing it in the correct position at the front to insure uninterrupted rolling over same by the first track wheel resulting in a continual smoothness of action for the entire unit.

The side bars are drop-forged and heat-treated. Track pins and bushings are of carburized and hardened steel. Identical in construction with the A-C Model "L" tractor. The shoes are special rolled section, flat type, reinforced to distribute strength uniformly over entire surface. Track and end wheels are mounted on anti-friction bearings.

This new wagon track has a net loading capacity of 15 to 20 tons. Overall dimensions of 80 in. long, 36 in. high, 19½ in. wide and the track shoes are 18 in. wide. These tracks weigh 5,252 lbs. per pair. The diameter of the axle bushings can be changed to fit any track wagon axle now on the market.

New Austin Motor Grader

A new motor grader has been brought out by The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill. This Austin Model 77 is powered with a 6-cylinder motor that develops 53 HP. at governed speed. There are six speeds forward, ranging from 1.39 to 13 M.P.H., to meet every operating need. The full dual drive puts all power to work behind the blade. Spinning or skidding wheel power losses are entirely eliminated. Four drive wheels grip the road surface to provide freedom from wheel slippage and miring. 80-in. wide front axle resists side draft, increases stability and makes machine easier to handle. Heavy Z-bar gooseneck has heavily machined, ball joint, non-chatter draft connection. All-over length of gooseneck is 96 in. 60-in. diameter circle provides more leverage when operating blade and has a five-point support. Wide blade arms are welded to circle. Both blade raising rods and hydraulic rams for operating circle have over-size finished ball and socket joints. Rugged ball and socket connections are also employed for joining blade arms to blade. Frame of 9-in. channel construction has welded steel plate bracing to resist strain and twist.



Austin Model 77 Motor Grader

The "77" is also built with single drive. All "77" motor graders can be furnished with either hand or hydraulic (oil) power controls; the "77" duel drive motor grader can be furnished with Diesel motor.

Extra equipment, including special blades, boots, extensions, etc., scarifier, power drag attachment, tire pump, snow plow, head and tail lights, etc., are available to meet every operating condition.

Wheeled Roller for Maintenance Work

A new roller for maintenance operations has been brought out by the Wheeled Roller Corp., Smith-Young Tower, San Antonio, Tex. A feature of the roller is that it can be hauled rapidly from one job to another on the rubber tired, Timken-bearing wheels. Once on the job by simply reversing the tongue by lifting it up and over the roller surface is brought in contact with the ground.

Roller in Operation on Patch Job. Note the Raised Wheels

An eccentric axle construction raises the wheels out of the way. The standard size for bituminous maintenance work has a roller width of 36 in. and a weight of 100 lb. per contact inch. The rollers can be furnished in weights up to 200 lb. per contact inch. In the standard size, should the owner desire to increase its weight for particular types of work, it is possible to add sand or dirt inside the roller drum through plates placed in the ends of the drum, and thereby increase the weight to approximately 170 lb. per contact inch of roller. The roller is mechanically constructed to withstand this, and additional weight. Standard equipment includes a water tank with a spray attachment and the necessary scrapers.

A Press for Straightening Concrete Forms

A press developed for the purpose of straightening the steel forms used in concrete road construction has been placed on the market by the Weaver Manufacturing Co., Springfield, Ill.

With this new press, which has a capacity of 60 tons, equipment is furnished to handle any part of a twisted or bent form. The work is done with speed and accuracy. The press will straighten short and long horizontal bends, surface bends, twists, sledge and hammer dents, etc. Additional work, such as removing and replacing gears, bushings, flywheels, etc., straightening all types of shafts, industrial track, mould boards for graders, etc., is accomplished with equal facility.

The work is always in direct contact with the press screw and the screw is quickly run down by means of the hand wheel. The high speed lever quickly handles work required to 2,000 lb. pressure

New Weaver Road Form Straightening Press

and pressures in excess of 60 tons may be easily developed by using the two levers on each side of press. The bolster is quickly raised and lowered by a crank on the side of the press.

Bulky work may be easily handled as the width between uprights of the press is 42 in. The height overall is 6 ft. 9 in. and the frame is of one piece steel channel construction. Floor space required 36x47 in. Shipping weight complete, approximately 1,000 lb. Vertical operation of the levers makes it necessary to bolt the press to a foundation, therefore it is readily portable.

New Caterpillar Grader

The No. 66 "Caterpillar" grader with full power control is announced by Caterpillar Tractor Co. of Peoria, Ill. The control unit is the same as the one used so successfully on the "Caterpillar" No. 77 grader. A 1-cylinder, air-cooled gasoline engine furnishes power to control 18 actions of the grader, including steering, leaning the wheels, raising and lowering the blade, turning and side shifting the circle, side shifting rear axle and operating the scarifier. Seven power control levers, grouped in front of the operator are equipped with automatic releases to protect the machine when the limit of any adjustment has been reached. Two of them may be shifted to control two separate adjustments. All gears are fully enclosed and run in oil.

Aside from the power control, this grader is identical with the hand controlled No. 66 "Caterpillar" grader previously announced. Both machines have 8-in. ship channel steel frames, adjustable bronze lift gears running on steel worms, ball and roller bearings throughout the lifting mechanism, one piece structural steel circle with carbon steel blade-beams riveted clear around the front, drop forged chrome-nickel steel axle spindles and non-buckling universal draft hitch. The power controlled model weighs 10,200 lbs. and the hand controlled model 9,763 lbs.

The 12-ft. blade, which is standard on both models, can be set to a maximum height of 9 ft. and an angle of 70 degrees for bank cutting. It has a side reach of 62 in. outside the rear wheels when set at a 45 degree horizontal angle.

New Highway Guard

A rotary highway guard, designed not only to withstand collision impact, but also to divert the car back into the line of travel, has been brought out by the Machined Steel Casting Co., Alliance, O. The installation consists of a horizontal pipe of 4-in. outside diameter, mounted on suitable bearings which permit it to rotate freely. It is claimed that when struck by the wheel of the car, which is rotating in a downward direction, the pipe is likewise set into an inwardly downward rotation, making it

Rotary Highway Guard

impossible for the wheel to climb over the guard and, instead, diverting the car back into the regular line of travel.

The pipe, which is supported by sturdy rolled steel standards rigidly bolted to a heavy concrete base, is placed sufficiently low to preclude any possibility of injury to fenders, bumper, hub caps, running board or body of the car. When a car crashes into the guard, the only part that makes contact with the guard is the tire. The rotating pipe is furnished ordinarily in 6 ft. lengths which permits the installation of a continuous guard closely following the contour of any curve. The guard is stated to be very simple in design and is readily assembled and disassembled.

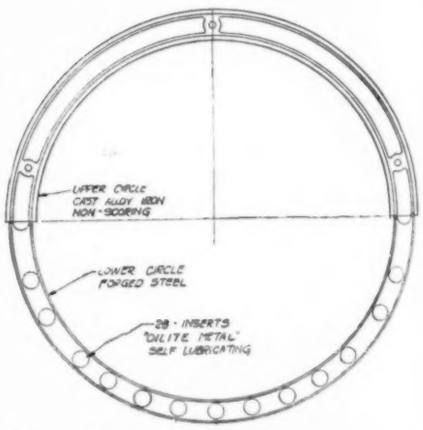
In addition to the ordinary functions of a highway guard, numerous other interesting applications have been suggested by the designers and incorporated in the design patents. For instance, a stand with double rolls has been designed to be used in heavy traffic lanes and tunnels, which would prevent cars side-swiping, there being enough distance between rolls to prevent damage to fenders and other protruding parts. Another suggested use is on high bridges and viaducts where the guard would be placed between the vehicular lane and footwalk as a precaution against cars climbing the curb and crashing through the railing. A special low design has been devised for mounting on curbs of city streets and highways which employ regular curbs extending above the pavement.

Improvement in Four-Wheel Trailer Design

The Fruehauf Trailer Co., Detroit, Mich., have just announced an improvement in the design of their 4-wheel trailers. A new type of bearing has been adopted for the circle which is claimed to insure complete lubrication at all times and yet demand little attention.

This new bearing is made from "Oilite" metal, which was developed by the Chrysler Corporation, and which is a self-lubricating bronze composition. This metal is 35 per cent oil by volume and the film of oil is brought to the surface by the load which is applied—and only at the points where pressure occurs.

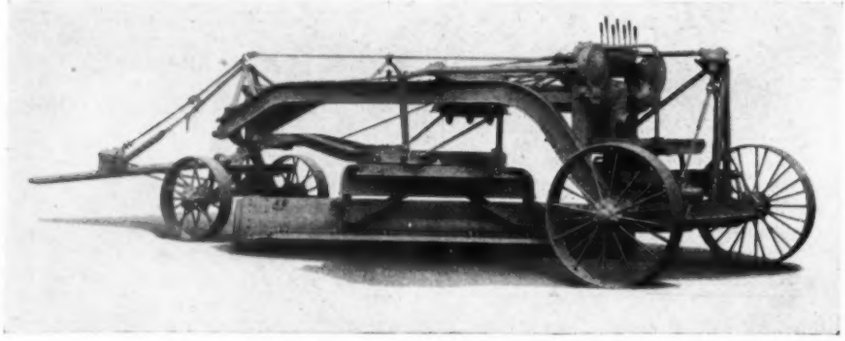
It is stated that these bearings are not affected by dust, dirt, corrosion or moisture and the only service necessary is to replenish the lubricant at intervals of six months to a year. This is accomplished



Sketch Showing Upper and Lower Circles

by separating the circles and brushing the surface of the bearings with ordinary motor oil. The metal acts as a blotter and immediately absorbs its full capacity of oil.

The sketch illustrates the upper circle which consists of a cast channel section of non-scoring, special alloy. The lower cir-



"Caterpillar" No. 66 Grader with Power Control

cle or ring is forged steel and has 28 inserts of the "Oilite" metal, these inserts serving as a bearing contact with the upper circle.

This new type of circle can be installed in trailers now in operation with very little trouble.

I-R Detachable Bits Marketed as "Jackbits"

"Jackbits" detachable rock drill bits designed to replace the conventional bits forged on the ends of drill steels, has been announced by Ingersoll-Rand Company, 11 Broadway, New York. They are secured

Ingersoll-Rand "Jackbit"

directly onto the end of the drill rod by means of a sturdy, shallow, reverse buttress-type thread of a carefully determined angle. This distinctive thread keeps the bit tight while in use and makes it easily detachable for changing. The maximum hammer blow is transmitted through the end of the rod, close to the cutting edge, and there is no pressure on the threads.

Other features pointed out by Ingersoll-Rand are large clearance grooves to pass cuttings from the bottom of the hole, a counter-sunk hole in the center of the cutting edge which acts as a pilot to guide the bit, and cadmium plating to prevent rusting and to give a bright finish which minimizes the loss of bits.

The hollow drill rods for "Jackbits" are made by the "super-smooth-hole" process, which has long been the Ingersoll-Rand standard. This method of manufacture is claimed to provide a smooth, uniform hole throughout the total length of the rod and to eliminate fatigue cracks and detrimental corrosive action which might result from rough hole surface.

A Spreader with No Moving Parts

A spreader for sand, slag, salt, calcium chloride, chips, gravel, cinders and stone, which spreads these materials uniformly to a width of 9 ft., has been announced by D. C. Elphinstone, Inc., 115 South Calvert St., Baltimore, Md.

The Best spreader consists of a series of troughs made of 14-gauge metal, the sides of which are 2 ins. high, the combined bottoms forming a flat, fan-shaped surface spreading the aggregate from the tail end of a dump truck. The front end, which attaches to the truck, is 6 ft. wide, and the back or discharge end is 8½ ft. wide; the length is 2½ ft. The Best spreader weighs 235 lbs., including two 5-ft. back-end hanging chains, by means of which the spreader is suspended from the back of the truck.

The Best Spreader

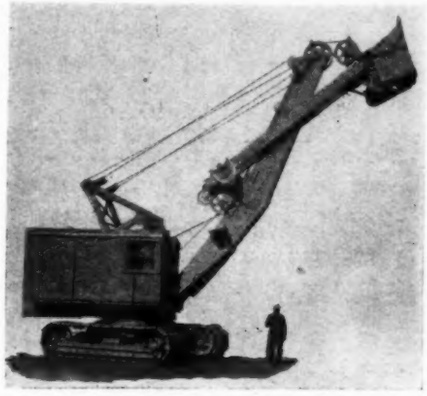
In operation, as the body is elevated and the tail gate opened, the material flows by gravity down the troughs and is discharged in a smooth sheet 9 ft. wide. The number of pounds of material per square yard of road surface to be spread is governed entirely by the width of the tail gate opening and the speed of the truck, and can be varied to suit all conditions.

The spreader can be installed by two men in two minutes and has no moving parts.

Northwest Announces a 2-Yd. Shovel

The Northwest Engineering Co., 28 East Jackson Blvd., Chicago, Ill., has announced a new shovel. This new shovel is known as the Northwest Model 80 and it has a capacity of 2 cu. yds. Both the boom and dipper sticks on this new shovel are of all welded construction. The boom is slightly cambered to make possible maximum operating ranges.

This new shovel is powered with a special 4-cylinder, 8 in. by 9-in. Northwest-



New Northwest 2-Yd. Shovel

Twin City gasoline engine, a heavy duty power plant operating at slow speed and capable of offering maximum resistance to the drag-down loads of rock digging. Exceptionally low fuel consumption is claimed for this engine.

Unusual mobility is claimed from the special Northwest crawler design which makes possible positive traction on both crawlers even while turning, assuring positive and easy steering under the worst conditions. It is claimed that the "Cushion Clutch" on the hoist drum transmits the full engine power but reduces the overload shocks 50 per cent.

The engine drive gears are mounted on ball and roller bearings and run in a bath of oil, in an oil tight housing. The gears have helical cut teeth assuring quiet operation and the maximum delivery of power.

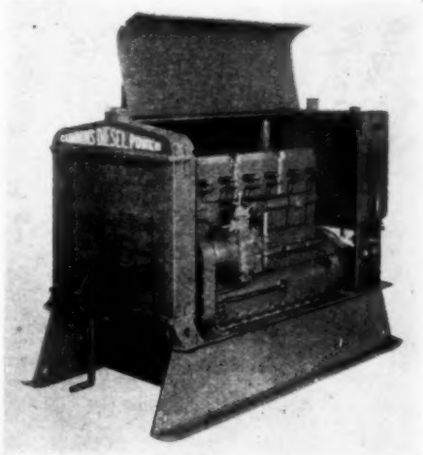
The "Feather-Touch" control shifts the main clutches, making operation fast and easy, and the operation of the clutch is in direct proportion to the pressure of the operator's hand on the lever.

All high speed shafts are mounted on self-aligning ball bearings.

Cummins Diesel Power Units

The Cummins Engine Co., Columbus, Ind., which has been building diesel engines for 15 years, now offers its "Model H," 4 and 6-cylinder, built up into complete power units.

These units are built up with the automotive type of Cummins diesel, both the 4 and 6-cylinder being 4⅞-in. bore by 6-in. stroke, the displacement being 448 and 672 cu. in. respectively. Governed at a maximum speed of 1200 R.P.M., these units



Cummins Diesel Power Unit

are rated at 55 HP. for the 4-cylinder and 83 HP. for the 6-cylinder.

The fuel system incorporates the exclusive Cummins principles of measuring, gasifying and injecting the fuel, which secures even firing, smooth operation, clean burning and economy of operation. Simplified design results in a very neat, compact, yet sturdy design, of lighter weight for diesel units. And volume production, due to many automotive users, made possible the complete tooling of a new modern plant.

All units are furnished very complete, yet are portable. The equipment furnished includes starting motor, generator, fuel oil tank (34 gal. capacity), air cleaner, radiator, fan, starting switch (and all controls in an instrument panel) and power take-off with clutch, including regularly an 8-in. shaft extension.

Concrete Aggregate Scale

A dial scale for weighing concrete aggregates for batch mixing is an addition to the line of Fairbanks, Morse & Co., 900 South Wabash Ave., Chicago, Ill.

The scale utilizes the pipe lever system of the 5-ton pitless scale securely mounted in an 8-in. channel frame from which is suspended a 20-in. portable type dial graduated 5,000 lb. by 5 lb. for the 1-yd. batch or 10,000 lb. by 10 lb. for the 2-yd. batch. A blank bar is provided for balancing the hopper. The dial equipped with special aluminum indicators for each ingredient, supported on a small bolt passing through a wire inserted plate glass and easily adjustable to the required weights by means of a wing nut and washers.

Dial Hopper Scale

Where the scale is mounted on top of the mixer, the hopper is extended up through the lever system; when hung below the bin, the hopper is suspended below the levers permitting the channel iron frame of the scale to be bolted directly to the timbers beneath the bunkers.

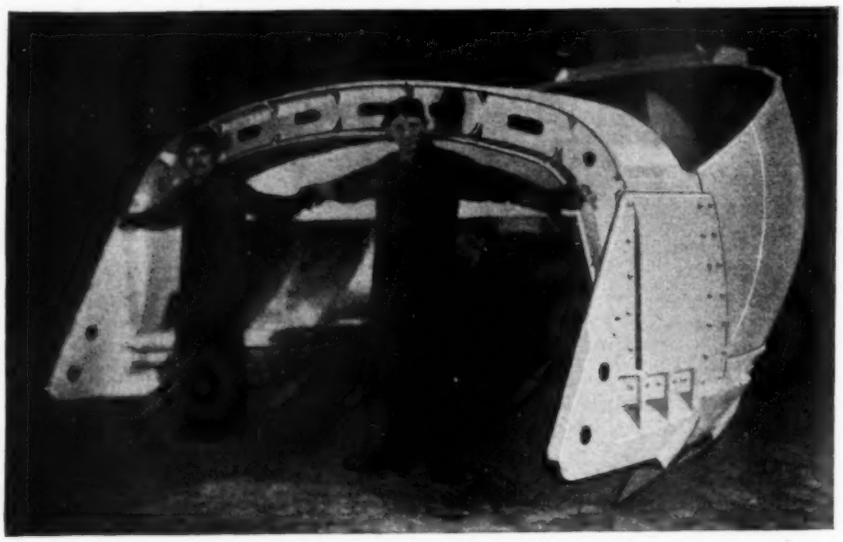
Most of the installations use the capacity poise and one of the indicators for large size gravel, the second indicator for the smaller gravel, the third for sand and the fourth for cement. In some cases, however, owing to rigid specifications, a separate scale and dial is required for weighing the cement.

Improved Crescent Type Drag Scraper

Important revisions have been made in the design of the Crescent type of drag scraper, manufactured by Sauerman Bros., Inc., 488 South Clinton St., Chicago, Ill. These revisions carry still further this principle of eliminating dead weight.

The new "Crescent" is of welded construction. It has a cast steel bail. Lip and end castings are of heat-treated alloy steel, providing great strength and resistance to crystallization. Tapered tooth sockets are cast integral with the lip, and renewable tooth points are fitted into these sockets. Each tooth point is held in place by a single bolt, the head imbedded in the tooth casting. The tooth has an octagonal tang, permitting it to be inserted with the direction of face at the most advantageous angle.

A number of the new Crescent scrapers of 12 and 15 cu. yd. capacities have been installed within recent months to replace scrapers of smaller capacities on tower machines owned by various earth-moving contractors and by the U. S. Government. All of these new scrapers have given a good account of themselves.



The New Crescent Type of Drag Scraper

New Self-Priming Centrifugal Pump

The Chain Belt Co., Milwaukee, Wis., announces a new 3-in. self priming centrifugal pump which rounds out its line of Rex speed primers. This new self priming unit is of the recirculating type, and is automatic in action after the recirculating system is once filled.

This particular size has been developed to provide a pump very close to the same light weight portability of the 2-in. class, with a greatly increased capacity. The new Rex meets the A. G. C. rating for 3-in. pumps with capacity to spare. The unit

New Rex 3-in. Pump

weighs only 385 lb., it is 34-in. high and 37-in. wide, and it is stated to be capable of the following capacities: 5 ft. suction lift—20,400 gal. per hour; 10 ft. suction lift—18,300 gal. per hour; 15 ft. suction lift—16,500 gal. per hour; 20 ft. suction lift—14,000 gal. per hour; 25 ft. suction lift —9,000 gal. per hour.

The Rex 3-in. pump incorporates the new and unique self priming device known as the Rex "prime control." With this simple mechanism the pump's recirculating system can be adjusted to assure maximum capacity and minimum priming time on any suction lift. It is claimed by the manufacturer that this new type recirculating system will pick up the prime in record time on any suction lift up to 25 ft. and it continues to pump with an air leak in the suction line that stops an ordinary centrifugal pump but only reduces the capacity of the Rex.